THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 23 JULY, 1923 No. 1

DISTRIBUTION OF THE DIPTEROCARPACEAE

ORIGIN AND RELATIONSHIPS OF THE PHILIPPINE FLORA AND CAUSES OF THE DIFFERENCES BETWEEN THE FLORAS OF EASTERN AND WESTERN MALAYSIA

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EIGHT PLATES

In discussing the biological differences between eastern and western Malaysia, and in attempting to explain the reasons for the manifest differences between these two regions, various authors have considered the mammals, birds, reptiles, batrachians, mollusks, fresh-water fishes, and insects with or without reference to the geology, paleontology, hydrography, and climate of the entire region. It has long been known that there are striking differences between the floras of eastern and western Malaysia, but hitherto no direct comparison seems to have been made between them. How significant these differences are is strikingly brought out on page 24.

In this paper the term Malaysia is used to define the entire region from the Malay Peninsula to New Guinea, including the Philippines. Western Malaysia includes the Sunda Islands and the Malay Peninsula, that is, Sunda Land of Molengraaff; eastern Malaysia includes all the Islands east of the Macassar Strait, including New Guinea. For purposes of discussion the Philippine Archipelago is considered as an independent area.

In discussing zoögeographic alliances one fact that must not be overlooked is that, before any considerable fauna can exist in any region, the vegetation must be present. In other words,

we must of necessity assume for the Philippines, for example, that our flora developed antecedent to much of our fauna. It is, therefore, assumed that the geographic distribution of generic types of plants characteristic of the primary forests of Malaysia, eliminating those known to be distributed by the wind and by water, which are comparatively few, forms a more-reliable basis for tracing previous land connections than does the present-day distribution of most groups of animals.

The sharply defined family Dipterocarpaceae is essentially confined to India and Malaysia. It has no representative in tropical America or in tropical Australia, while in Africa it is represented by a single species of the genus *Vatica* and by thirteen species of the anomalous genus *Monotes*, which some authorities do not admit as a member of this family.

As at present understood, including the African genus *Monotes*, the family comprises seventeen genera and about three hundred seventy-seven species.[1] Excepting the African genus men-

TABLE 1.—*Geographic distribution of the genera and species of Dipterocarpaceae.*

Genera.	Total species.	Africa.	Seychelles.	Ceylon.	India.	Eastern Peninsula.	Sunda Islands.	Philippines.	Eastern Malaysia.
Anisoptera	16					6	4	4	4
Balanocarpus	17			1	2	8	5	2	
Cotylelobium	6			1		2	4		
Dipterocarpus	69			5	2	29	28	15	
Doona	12			12					
Dryobalanops	6						6		
Hopea	56			3	4	18	28	7	3
Isoptera	2					1	2	1	
Monoporandra	2			2					
Monotes	13	13							
Pachynocarpus	5					2	3		
Parashorea	5					1	2	2	
Pentacme	5					3		2	
Shorea	95			6	3	41	46	13	3
Stemonoporus	13			13					
Vateria	3		1	1	1				
Vatica	52	1		3	1	24	16	4	4
Total species	377	14	1	47	13	135	144	50	14

[1] This estimate is primarily based on Brandis, D., An enumeration of the Dipterocarpaceae, Journ. Linn. Soc. Bot. 31 (1895) 1–148, *t. 1, 2.* His figures have been modified by certain reductions and transfers made since his paper was published, and species described since 1895 have been added.

tioned above, one species of *Vatica* that occurs in Africa, and a single species of *Vateria* that occurs in the Seychelles, the family is confined to India, Ceylon, the Eastern Peninsula (one *Shorea* in southeastern China and one *Vatica* in Hainan), the Sunda Islands, the Philippines, the Moluccas, Celebes, and New Guinea.

The Sunda Islands taken as a whole, that is, Sumatra, Java, Borneo, and the smaller intervening islands such as Bangka, Billiton, and Lingga, present the most numerous species, totaling one hundred forty-four in eleven genera. Of this area Borneo is specifically the richest in dipterocarps, presenting eleven genera and one hundred three species. The total number of species known from Sumatra is comparatively small, in all probability due chiefly to the fact that the Sumatran flora is very imperfectly known. The dipterocarp flora of Java is likewise poor, but this may be explained by the assumption that some dipterocarps that may have existed in Java have been exterminated in comparatively recent times, that is, within the past few centuries, through the almost complete destruction of the primary forests throughout Java below an altitude of 1,200 meters. Everywhere in Malaysia the destruction of the low-altitude, primary forest means the destruction of the dipterocarps. The Eastern Peninsula, from Assam through Burma, Siam, Indo-China to the southern part of the Malay Peninsula, presents eleven genera and one hundred thirty-five species.

The next richest area is the Philippines, with nine genera and fifty species, our dipterocarps being distributed throughout the Archipelago from Tawitawi in the Sulu Archipelago and Palawan through Mindanao and the central part of the Archipelago to northern Luzon and the Babuyan Islands. Five species in five genera occur in the latter group, between Luzon and Formosa. No representative reaches Formosa, and only a single species of *Shorea* is known from the southwestern part of Kwangtung Province, China, while a single species of *Vatica* occurs in Hainan.

India proper presents only thirteen species in six genera. In striking contrast to this, the small island of Ceylon presents no less than forty-seven species in ten genera, approximately the same number of species and genera as occur in the entire Philippine Archipelago. The Ceylon dipterocarp flora is further remarkable for its very definite endemism, the genus *Doona* with twelve species, the genus *Monoporandra* with two species, and the genus *Stemonoporus* with thirteen species being confined to

Ceylon; furthermore, the genus *Vateria* presents but three species, one occurring in Ceylon, one in India, and one in the Seychelles.

Perhaps the most striking feature in the distribution of the dipterocarps is their paucity in eastern Malaysia; that is, in the entire region extending from Celebes southward to Lombok, and eastward through the Moluccas to New Guinea, where only fourteen species in four genera are known. Four of these belong in the genus *Anisoptera,* three in the genus *Hopea,* three in the genus *Shorea,* and four in the genus *Vatica.* All of these genera are of wide geographic distribution, represented in most of the regions in which the family occurs. The genera *Hopea, Shorea,* and *Vatica* are three of the four large genera in the family. It seems probable, however, that the number of species generally recognized as occurring in eastern Malaysia is too high. Dr. D. F. van Slooten, who is now engaged in a general study of the Dipterocarpaceae of Malaysia, informs me under date of February 4 that, so far as his studies have been completed, he is of the opinion that the two species of *Anisoptera* described from New Guinea, and perhaps the undescribed one mentioned by Dyer, must be reduced to *A. polyandra* Blume. He is further of the opinion that the three species of *Vatica* recorded from the Moluccas should be reduced to a single one, *V. papuana* Dyer. The reduction in the number of species of *Vatica* is, however, counterbalanced by two apparently undescribed forms represented in the Buitenzorg Herbarium by imperfect material from Celebes.

It is perfectly evident that the Eastern Peninsula and the Sunda Islands are essentially the regions in which the family has reached its maximum development in genera and in species. India may possibly have supported a much richer dipterocarp flora in the past than to-day; this is especially probable in view of the fact that the comparatively small island of Ceylon, off the southern end of the Indian Peninsula, presents so many more genera and species than does the entire Western Peninsula.

In view of the large development of this family in the Sunda Islands, the Eastern Peninsula, and the Philippines, its slight development in eastern Malaysia, and the peculiar biological characters of the group (see p. 6), a study of the geographic distribution of the Dipterocarpaceae in the entire Malaysian region is of very special interest. This interest lies in a logical

explanation of the differences between the floras of eastern and western Malaysia, and why the Philippines, lying to the northeast of the Sunda Islands or western Malaysia and north and northwest of eastern Malaysia, presents in its flora elements from both of these two rather sharply differentiated regions of the Malay Archipelago.

We know comparatively little regarding the geological history of the Dipterocarpaceae. Brandis [2] states regarding the five fossil species, described by Geyler from Borneo and Labuan and placed in the genera *Hopea* and *Dipterocarpus*, that the fragments show no characters which necessitate their being placed in this family. He considers that the only fossil remains described up to 1895 that could safely be classed here are those described by Heer from the Tertiary deposits of Sumatra. Heer describes two species of *Dipterocarpus*, one of which Brandis thinks probably was a species of *Shorea*. Brandis concludes that the fossil remains, therefore, throw no light upon the development of this family.

Comparatively little additional information regarding fossil Dipterocarpaceae has become available since Brandis's work was published. Holden [3] has described a fossil genus, *Dipterocarpoxylon*, from the Tertiary of Burma, based on fossil wood of a single species. Colani [4] has described another species of this genus from Tertiary material supposed to have come from Annam.

Schuster [5] records *Hopea fagifolia* Miq. and *Vatica lancifolia* Miq. from the Trinil beds in Java (Pleistocene). There seems to be no question that Schuster's identification of these fossil remains is correct.

Edwards [5a] has very recently described a new genus and species, *Dipterocarpophyllum gregoryi*, from the Tertiary of southeastern Burma which, however, is in all probability not distinct from some living genus. He cites Crié's description of

[2] Brandis, D., An enumeration of the Dipterocarpaceae, Journ. Linn. Soc. Bot. 31 (1895) 4.

[3] Holden, R., Records Geol. Surv. India 17 (1916) 267.

[4] Colani, M., Service Geol. Indochine Bull. 6 [3] (1919) 2.

[5] Schuster, S. J., Monographie der fossilen Flora der Pithecantropus-Schichten (1911) 1–70, *t. 1–27*. Reprint from Abhandl. Kgl. Bay. Akad. Wissensch. Math.-Phys. Klasse 25 (1911).

[5a] Edwards, W. N., On some tertiary plants from South-East Burma, Geol. Mag. 60 (1923) 159–164, *t. 5*.

Phyllitis dipterocarpoides from the Pliocene of Java, which is compared to the living *Dipterocarpus baudii* Korth., Kraüsel's *Dipterocarpoxylon tobleri* from the Miocene of Sumatra, and also the latter's reference of *Grewioxylon swedenborgii* Schuster from the East Indies to *Dipterocarpoxylon,* together with the description of *D. javanense* Kräusel from the Tertiary of Java. He further notes that *Woburnia porosa* Stopes, from the English Lower Green Sand (Lower Cretaceous) has been compared with the Dipterocarpaceae, thus indicating that the family may have had a long geologic history and a more-extended distribution in the past.

Fossil Dipterocarpaceae found in the Philippines and appertaining to the genera *Anisoptera* and *Shorea,* like those of the Trinil formation in Java, are absolutely identical with species now living in the Archipelago. The formation at Sagada, Luzon, which has yielded a large number of leaf impressions, is Pliocene. The Dipterocarpaceae represented here are *Anisoptera thurifera* Blume, *Shorea guiso* Blume, and *S. polysperma* Merr. Genera of other families, such as *Calophyllum, Beilschmiedia, Diplodiscus, Cinnamomum,* and *Phoebe,* are represented only by existing forms, and all species found are associates of the dipterocarps in our low-altitude primary forests of to-day.

We now know enough of the geological history of the Dipterocarpaceae to state definitely that this family was developed and widely distributed in India and Malaysia in late Tertiary times, and that it probably developed as a family in southern Asia and in what is now western Malaysia when the Sunda Islands were united with the Asiatic continent. It arose, perhaps, in the early Tertiary or in the late Mesozoic. So far as the Philippines is concerned, our Dipterocarpaceae reached the Archipelago during the Pliocene or earlier, as, judging from the nature of the fossil deposits known in Luzon, representatives of this family were apparently dominant in the primary forests of that time, as they are to-day.

It is a peculiar biological character of this family that, with almost no exception, the numerous species are essentially confined to the primary forests. They do not thrive in the open country and are never components of young secondary forests or of forests that rapidly spring up in deforested areas that are allowed to revert from cultivation where grass fires are not a

limiting factor. Brandis[6] has called attention to the fact that not only are various species gregarious or semigregarious, but the sal, *Shorea robusta* Gaertn. f., stands much shade when young. Brown[7] verifies this observation in the case of the Philippine *Parashorea malaanonan* (Blanco) Merr.; his data and graph showing the rates of growth indicate clearly that *Parashorea* withstands a greatly prolonged suppression period. This is especially true of the seedling and sapling stages where the start is made in the virgin forest. Brown shows that the suppression period is so great in the primary forest that as much as seventy years may elapse before the trunk attains a diameter of 5 centimeters, although the rate of growth after this long suppression period is very rapid. It would seem that all or most dipterocarps have this adaptability to a long supression period in early life; hence their ability to thrive in and eventually to dominate the dense primary forests of India and Malaysia.

Most dipterocarps have winged fruits, yet they are definitely not adapted to wide dissemination by wind. The fruits are in general too heavy for wind distribution, while the wings are adapted to provide a gyratory motion in falling, rather than for horizontal distribution. Except in the genera *Vatica* and *Isoptera,* the seeds or fruits do not present the slightest adaptation for dissemination by water. Burkill[8] briefly discusses the adaptation of the fruits of *Vatica wallichii* Dyer and *Isoptera borneensis* Scheffer for dissemination by water. He finds that the fruit of the former floats for an average period of twenty-two days, while that of the latter, deprived of its corky sepals, sinks within a period of sixty hours. He states that it is not possible to regard water distribution as in any way ancestral in the order. Generally speaking, the seeds of the dipterocarps are noted for their brief period of viability; they do not in general withstand drying out, which is perhaps one very potent reason for their practical nonoccurrence in open places. The trees from seed and seedling stages to full maturity are clearly adapted to the shade, temperature, moisture, and light conditions characteristic of the dense tropical primary forests of India and Malaysia. To

[6] Brandis, D., Journ. Linn. Soc. Bot. **31** (1895) 6.

[7] Brown, W. H., Vegetation of Philippine Mountains, Bur. Sci. Publ. **13** (1919) 157, *fig. 2*.

[8] Journ. Straits Branch Roy. Asiatic Soc. **86** (1922) 276, 281.

one, then, familiar with the dipterocarps as they occur in nature, with the habitat complex of most or all species, with their seed and seedling characters, and especially with their peculiarly short-lived seeds, it becomes perfectly evident that, in order to explain their present geographic distribution, it is absolutely necessary to postulate previous land connections from India to New Guinea over which, at some time in geologic history, it has been possible for certain species to march unimpeded.

From the geologic history of the Philippines we know that its present fauna and flora, or their ancestors, originated outside of the present-day limits of the Archipelago; no geologic formation earlier than the Jurassic is known from the Archipelago. From the very nature of the Dipterocarpaceae they must have originated in a forested region; therefore, the Philippines must have been a forested region before the dipterocarps arrived. The rate of dissemination of the dipterocarps is relatively slow, so that a long period must have elapsed during which land connection existed between the Philippines and western Malaysia, over which the trees migrated. From the adaptability of these trees to primary forest conditions (soil, humidity, rainfall, and temperature conditions practically wherever they occur with us being favorable to their development) they have become dominant.

Dipterocarp forests are tall, characteristically low-altitude, tropical ones of India and Malaysia, and usually occupy localities most favorable to tree growth. They occur on all types of topography, but are usually best developed on well-watered and well-drained plains and on the lower gentle slopes of the main mountain masses. They thrive best perhaps in the humid localities of Malaysia, where dampness and humidity are always so great that forest fires are unknown; yet in some regions, such as Bengal, the sal (*Shorea robusta* Gaertn. f.) thrives in localities where the dry season is so pronounced that fires cause considerable damage to the forests. While most of the species are very strictly tropical and, in the Tropics, low-altitude forms, the sal occurs in some parts of Bengal where it is injured by frost.

The dipterocarp forests of the Philippines reach their maximum development below an altitude of 700 meters, and ordinarily few species are found at or above an altitude of 800 meters. In Luzon and the central Philippines the only species recorded from altitudes of 800 meters are *Vatica mangachapoi* Blume and *Shorea polysperma* Merr., and we have no records

of these from above that altitude. On the authority of Mr. A. D. E. Elmer, we find in Mindanao *Parashorea warburgii* Brandis, *Shorea squamata* Dyer (= *S. palosapis* Merr.), and *S.* sp. at 1,000 meters altitude, and *Vatica mindanensis* Foxw. at 1,100 meters altitude.

In connection with the altitudinal range of the Dipterocarpaceae in the Philippines, it is interesting to compare the data compiled by Brown [9] in the midmountain forests of central Luzon; that is, between 600 and 900 meters altitude. At an altitude of 700 meters a plot 50 meters square was selected with the same slope and exposure as those of the plot surveyed in the dipterocarp forest at 450 meters altitude. In this plot he found five hundred seventy-eight individual trees, representing thirty-nine species, but the Dipterocarpaceae were entirely absent. However, most of the species found in this plot occur also in the dipterocarp forest at lower altitudes. In other words, Brown definitely shows that the Dipterocarpaceae are strictly limited as to their altitudinal range, while representatives of many other families and genera, which are associated with the Dipterocarpaceae and form the complex, low-altitude forests of the Philippines, thrive at altitudes distinctly higher than the Dipterocarpaceae themselves.

Brown states that in the transition from the dipterocarp to the midmountain forest the change from one association to another is usually gradual and is marked by intermediate conditions. The tall trees characteristic of the Dipterocarpaceae that form the upper story of the typical dipterocarp forest gradually disappear, and the first story of the *Quercus-Neolitsea* association of the midmountain forest is approximately of the same height and composed largely of the same species as the second story of the dipterocarp forest. There is no marked change in the composition of the minor elements in the transition zone.

In reference to the altitudinal range of the dipterocarps outside of the Philippines, Mr. I. H. Burkill, Director of the Botanic Gardens, Singapore, informs me under date of January 8 that, on the main range of the Malay Peninsula in the neigborhood of Semangkok Pass, he and Mr. Holttum found that they disappear at an altitude of about 1,050 meters without apparent dwarfing. The forest here at an altitude of about 1,200 meters

[9] Brown, W. H., The Vegetation of Philippine Mountains (1919) 76–97.

is 30 meters high but, with the intrusion of the dipterocarps at and below 1,060 meters, the height abruptly increases to 60 meters.

In most dipterocarp forests the ground is bare and herbs are scarce. In the *Quercus-Neolitsea* association of the midmountain forest there is in most places a well-developed ground covering of herbs. The change takes place not in the tension zone between the two associations but in the upper part of the dipterocarp forest. Brown further calls attention to the fact that the midmountain forest is more open than the dipterocarp forest, but here again the change is a gradual one and begins in the upper part of the dipterocarp forest; he states, furthermore, that the increase of epiphytes is much greater in the midmountain forest, this being due to the general complex of conditions that cause increased epiphytic vegetation as higher altitudes are reached. There is no marked change either in amount or composition of this vegetation on the border between these two associations. In these midmountain forests there are no dominant trees corresponding to the dipterocarps in the forests at lower altitudes.

To those unacquainted with the primary forests of India and Malaysia it is difficult to convey an impression of how absolutely dominant the dipterocarps are in these vast forested areas. Brandis has emphasized the fact that numerous species are gregarious, forming nearly pure stands of large extent where single species occur to the practical exclusion of all others. He is entirely correct in his statement that the dipterocarps in the tropical forests of eastern Asia play the rôle which in Europe (and for that matter North America) belongs to the Coniferae and Cupuliferae. The most noted gregarious species is the sal, *Shorea robusta* Gaertn. f., which forms pure or nearly pure forests of vast extent in the Himalayan foothills and in eastern central India. Brandis enumerates seventeen species in seven genera that are known to be gregarious. In addition to these gregarious species very many more are semigregarious; but practically wherever they occur, even though as scattered individuals, they dominate and give character to the forests on account of their great size (see Plates 3–8).

Owing to the fact that these forests contain a high percentage of commercial timber, they have been intensively studied in India, Malaysia, and the Philippines. The Philippine diptero-

carp forests have been especially considered by Whitford,[10] by Brown and Matthews,[11] and by Brown.[12]

Whitford,[13] in discussing the dipterocarp forests on the lower slopes of Mount Mariveles in Bataan Province, Luzon, enumerated the trees in four plots, varying in size from 300 to 750 square meters, between altitudes of 260 and 410 meters. He found in these plots three hundred eighty-eight individual trees, representing eighty-eight species, of which six species were representatives of the Dipterocarpaceae. Three species, namely, *Dipterocarpus grandiflorus* Blanco, *Shorea polysperma* Merr., and *Parashorea contorta* Merr. and Rolfe, comprised 31.6 per cent of all the trees in the plots mentioned, and further, with the exception of one species of *Calophyllum,* one species of *Santiria,* one of *Eugenia,* and a few others, these trees made up nearly the whole of the upper-story vegetation. The other dipterocarps in the plots were *Anisoptera thurifera* Blume, *Hopea acuminata* Merr., and *Dipterocarpus vernicifluus* Blanco. Brown [14] enumerated the individual trees growing on plots 50 meters square on the lower slopes of Mount Maquiling, Laguna Province, Luzon. In one plot at 450 meters altitude in a virgin dipterocarp forest he found three hundred fifty-three individual trees, representing ninety-two species, of which three species and twenty-nine individuals were Dipterocarpaceae. In a culled dipterocarp forest at an altitude of 200 meters, of the same area as the one discussed above, he found a total of eight hundred eighty-seven individual trees representing one hundred twenty-nine species, the Dipterocarpaceae being represented by three species and eighty-one individuals. Even when the individual dipterocarps are few in number they dominate the forest by their great size (see Plates 5 and 6).

After this preliminary examination of the geographic distribution of the dipterocarps, a brief discussion of the paleobotanical data available, the peculiar biological characters of the family, and a general description of the dipterocarp forests in

[10] Whitford, H. N., The vegetation of the Lamao forest reserve, Philip. Journ. Sci. 1 (1906) 373–431, 637–682, *t. 1–45.*

[11] Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, Philip. Journ. Sci. § A 9 (1914) 413–561, *t. 1–13.*

[12] Brown, W. H., The Vegetation of Philippine Mountains: The relation between the environment and physical types at different altitudes, Bur. Sci. Publ. 13 (1919) 1–434, *t. 1–41,* pp. 27–75.

[13] Op. cit. 640.

[14] Op. cit. 440.

which the absolute dominance of the dipterocarps in the typical primary forests of Malaysia is brought out, we may now take up the significance of the dipterocarp distribution in the Malay Archipelago.

We have already noted (p. 3) that the two rich areas are the Eastern Peninsula, with eleven genera and one hundred thirty-five species, and the Sunda Islands, with eleven genera and one hundred forty-four species, while the Philippines stands third, with nine genera and fifty species. Why do we not find the family strongly developed in the islands south of the Philippines and east of the Macassar Strait between Borneo and Celebes, or Wallace's Line? It has been noted above that in this vast region only fourteen species in four genera are known. Had there been a continental area extending from Sumatra to New Guinea at any time while the Dipterocarpaceae was developing its geographic distribution, we should certainly expect to find approximately as many dipterocarps in eastern Malaysia as we do in western Malaysia, or at least as many as in the Philippines. In the entire region from Celebes to New Guinea climatic and other factors are approximately the same as in western Malaysia; in other words, the entire region is essentially adapted to the requirements of the Dipterocarpaceae. Celebes is also infinitely closer to Borneo geographically than is the main part of the Philippine group.

In past geologic times much of the area between southeastern Asia and Australia has been occupied by epeiric seas. Dr. Roy E. Dickerson calls my attention to the facts that Java, Sumatra, and Borneo are in large part covered by marine Tertiary sediments and that New Guinea is also largely composed of similar sediments; the sediments in British New Guinea are largely Miocene. The islands of Java, Sumatra, and Borneo on the one hand, and New Guinea on the other hand, are land masses associated with shelf seas which have consequently during Tertiary times been alternately dry and flooded by shallow seas. Practically throughout the Tertiary New Guinea, Celebes, Borneo, Java, and Sumatra have changed their patterns from epoch to epoch. During the Pleistocene Java, Sumatra, and Borneo were alternately connected and disconnected with the Asiatic mainland, and New Guinea was alternately connected and disconnected with Australia. Formosa has had the same history in reference to Asia. The great difference between the regions now delimited by the Asiatic and Australian continental shelves and the intermediate insular area (the stress area between these two

great continental shelves), is the presence of great development during Pleistocene times in the intermediate stress area of very notable marine deeps and corresponding upthrust island masses.

In the Philippines there is strong suggestive evidence that some of our deeps, such as those connected with the Formosan and Mindanao Rift systems, were formed and reformed repeatedly during the Tertiary. There is even stronger evidence to show that the Formosan Rift originated in the Tertiary and that movements along this great rift during that time have maintained a constant separation between Formosa and the Philippines. Doctor Dickerson concludes, from a study of the Malumbang strata, which is widely distributed in the Philippines, that only shallow seas existed in the Philippines during the Pliocene. In the Philippines the earliest geologic formations that have been recognized are the Jurassic of the early Mesozoic. The Cretaceous, the Eocene, and the Oligocene formations are absent in the Philippines, or at least have not been recognized by geologists, so far as geologic exploration of the Archipelago has progressed.

Molengraaff's [15] concise summary of our present knowledge of the land and sea areas in the Malaysian region gives us the clue to the cause of the biological differences between eastern and western Malaysia. His very definite conclusions cannot be ignored by any student of the distribution of the flora and fauna of this region.

In the Asiatic-Australian region there have been two definite continental platforms now delimited by the Asiatic and the Australian continental shelves, and since the early Tertiary these have been separated by an area which has been constantly in an archipelagic condition. The 200-meter line may be conveniently taken as delimiting these continental shelves, but the average depth of the water on these shelves is only 60 meters. The Asiatic shelf carries upon it all the Sunda Islands, Sumatra, Java, Borneo, and the intervening smaller islands; the Australian shelf carries upon it the great island of New Guinea. In the Pleistocene and, probably, in the immediately preceding epoch Sumatra, Borneo, Java, and the islands eastward of Java to and including Bali, as well as the Balabac-Palawan-Calamian group in the Philippines and probably the Sulu Archipelago, were connected at times with the Asiatic continent via Borneo, and New Guinea was connected with Australia.

[15] Molengraaff, G. A. F., Modern deep sea research in the East Indian Archipelago, Geogr. Journ. 57 (1921) 95–121, *figs. 1–9*, map.

Interposed between these two continental platforms we have an intermediate area radically different in its physical features and in its Pleistocene geological history. This area is one of inclosed, troughlike sea basins of great depth, ranging from 1,200 to 6,000 meters; elongated islands, mostly presenting very considerable altitudes, their elongation parallel to the troughs; the troughlike basins and the islands arranged in curved lines; and the islands presenting very conspicuous signs of comparatively recent elevation. This modern elevation in the Philippines in places exceeds 1,500 meters. Most of the inclosed deep sea basins are in the eastern part of the Archipelago; none of them actually occur within the limits of the area outlined by the Malay Peninsula, Sumatra, Java, and Borneo (see Plate 1).

Molengraaff's contention that there is a genetic connection between the subsidence of the trough-shaped deep sea basins and the elevation of the adjoining, elongated, paralleling, elevated islands is an entirely logical conclusion. The explanation is a crustal movement in a process of folding or faulting at a certain depth. In other words, we have a large stress area, orogenetically still active and as a result unstable, situated between two stable areas, the latter delimited by the Asiatic and Australian continental shelves. This unstable area extends from Lombok and Celebes to near western New Guinea and northward through most of the Philippine group. This entire stress area has been orogenetically active and hence unstable from the Pleistocene, and possibly earlier. It has in consequence been archipelagic rather than continental, at least since the beginning of the Pleistocene. There have been intermittent land connections eastward to New Guinea, northward to the Philippines, and apparently southwestward and westward with Java, but probably during the entire Tertiary there was no direct connection across the narrow Macassar Strait between Celebes and Borneo.

In interpreting probable previous land connections on the basis of the present distribution of plants and animals it is difficult to assign definite values to special groups. We merely know that mammals generally cannot swim across broad separating seas; true fresh-water fishes are also thus limited; batrachians, while adapted to terrestrial life, are primarily adapted to fresh-water marsh conditions, and cannot live in salt water; lizards and snakes are apparently better adapted to fortuitous distribution from one island to another by drift than are the mammals as a group, certainly the larger mammals; birds, bats, and most insects, of course, have the advantage of flight, yet many groups

of birds and insects are curiously limited in distribution, indicating that some at least do not extend their range except over continuous land areas. Each specialist is, of course, interested in his own group, and it is but natural that he should be influenced in his deductions by his own special knowledge and his own special interests. Thus Pelseneer,[16] on the basis of certain geographic distributional studies, abandoned Wallace's Line and constructed a new one east of Celebes and Timor; this new line, which he called Weber's line, is absolutely untenable when all groups of animals are considered, even as Wallace's Line is untenable as an absolutely separating boundary.

Weber's Line is, however, apparently the approximate eastern boundary of the geologically unstable intermediate insular area, and bears much the same relationship to the Australian continent that Wallace's Line bears to the Asiatic continent. It seems to be clear that different portions of these lines have distinctly different values (see Plate 2).

Wallace's Line, so named by Huxley, was placed between Bali and Lombok, extending northward through the Macassar Strait between Borneo and Celebes and thence turning to the eastward between Celebes and Mindanao, extending into the Pacific Ocean. It was based on observations and published statements of Alfred Russell Wallace regarding the evident differences in the biology of eastern and western Malaysia. Critics of Wallace's Line have not always been entirely fair to Wallace. In his Island Life he clearly states that Celebes, although included by him in the Australian region, from a balance of considerations, almost equally belongs to the Oriental Region, and that it consequently must be left out of account in the general sketch of the zoölogical features of the Australian Region. Again, he speaks of it as an "anomalous island" because both by what it has and by what it wants it occupies such an exactly intermediate position between the Australian and Oriental Regions.

In reference to the position of Wallace's Line, our present data seem to show that this fundamental dividing line does not turn to the east between Celebes and Mindanao, but extends northward through the Sibutu Passage, the Sulu Sea, and the Mindoro Strait between the Calamian group and Mindoro, thence northward and then eastward between Formosa and the Batan Islands into the Pacific. The extension of this line north of

[16] Pelseneer, P., La ligne de Weber, limite zoologique de l'Asie et de l'Australie, Bull. Acad. Roy. Belg. (1904) 1001–1022.

the Macassar Strait, like its southward extension between Bali and Lombok, has not been of so long-continued and permanent a nature as the Macassar Strait (see Plate 2).

Weber's Line extends between Timor and Australia, running northwestward between the Kei and Aru Islands, then turns to the northeast and east through the Ceram Sea north of Ceram and Buru, and finally northward through the Molucca Passage and into the Pacific Ocean between Celebes and Halmaheira. Molengraaff[17] states that the trough sea or series of trough seas consisting of the Timor Sea separating Timor from Australia, the Kei trough, the Ceram trough, and the Ceram Sea is a most important geologic boundary, as it separates totally different structures from each other. He states that the nonvolcanic islands of this arc originated as oceanic ones by anticlinal folding and that, geologically, they stand in close relationship with eastern Asia but have no connection at all with Australia. If we are to accept a geologic boundary between Australia and Asia, then the boundary must be drawn between Timor and Australia and between Ceram and New Guinea. This sharp geologic boundary is also an important dividing line from a zoögeographic standpoint, as Weber has pointed out, for the fresh-water fishes. Molengraaff notes that the boundary is not so sharp a dividing line in other groups of animals as is the case with the fresh-water fishes but, in spite of this, it is important for all groups. It would seem that the significance of Weber's Line, like that of Wallace's Line, as a biological boundary, is due primarily to fundamental geologic conditions. Wallace's Line cannot be abandoned in favor of Weber's Line or vice versa; the former is merely the eastern boundary of the unstable insular area, and the latter is apparently the approximate western boundary of the same terrane and bears much the same relationship to New Guinea and Australia as Wallace's Line bears to Asia or, rather, the former eastern boundary of the Asiatic continent.

Weber,[18] followed by Van Kampen,[19] has clearly shown that the entire region from Celebes and Lombok to New Guinea is a

[17] Geologie in: De zeeën van Nederlandsch Oost-Indië (1921) 272–357, *t. 1–7.*

[18] Weber, M., Der Indo-australische Archipel und die Geschichte seiner Tierwelt (1902).

[19] Van Kampen, P. N., De Zoogeografie van den Indischen Archipel, Nat. Tijdschr. Nederl. Ind. (1909) Bijblad 3, 4; English translation, Am. Nat. 45 (1911) 537–560.

transition one, in which the Indian and Australian faunas mingle, where from east to west Australian types diminish rapidly, and where from west to east the Asiatic types decrease. The decreases are most startling in some groups, for instance, the true fresh-water fishes. In this group Sumatra presents two hundred twelve species, Borneo two hundred ninety-two, Java one hundred thirty-one, and Celebes only four. Such distribution is significant in itself. A very few fresh-water fishes entered Celebes by some fortuitous circumstances, and it is not at all surprising that one entered Lombok. Weber [20] thus lays entirely undue stress on the finding of a single cyprinoid in Lombok, overlooking the real significance of the very numerous cyprinoids in "Sunda Land" and their entire absence east of Lombok and Sumbawa. Here is a most excellent illustration of an efficient and long-continued barrier to the migration of the fresh-water fishes eastward in the form of narrow arms of the sea which they could not cross. That a very few, by fortuitous circumstances, did succeed in crossing this line in several hundred thousand years, is utterly insignificant in view of the very large number that occur west of this line.

Barbour [21] states the case thus:

> Neither Wallace's nor any other line can be held to form a real zoölogical boundary. A transition zone *with a fairly definite western frontier* [italics mine] and with an eastern frontier incapable of equally clear definition seems really to be the condition which serves to separate the Malayan from the Papuasian subregions. This zone may be about equally well defined for any of the groups of land animals, and the boundaries for the distribution of the several groups coincide with reasonable accuracy.

It is realized fully that the region under discussion is a transition one; that no sharp line can be drawn anywhere that will separate the Australian and Asiatic floras and faunas, or those of eastern and western Malaysia, when all groups are taken into consideration. The real significance of Wallace's Line is that it delimits and separates two regions that fundamentally have had a different geological history; one at times a continent over which plants and animals could march unimpeded except by such barriers that continents usually present, the other a constant archipelago where intermigrations have been inter-

[20] Weber, M., Siboga-Expedetie. Introduction et description de l'expédition (1902) 16.

[21] Barbour, T., A contribution to the zoögeography of the East Indian Islands, Mem. Mus. Comp. Zool. Harvard Univ. 44 (1912) 1–203, *t 1–8*

rupted by deep arms of the sea since the early Tertiary at least. The "fairly definite western frontier" of Barbour is Wallace's Line. In the unstable area land connections between what are now individual islands have been intermittent and, as between these islands and the lands to the east and west, the connections have apparently never been more than narrow isthmuses. In other words, intermigrations in the entire region from Lombok and Celebes eastward to New Guinea and northward through the Philippines have been inhibited by the generally constant archipelagic condition of the entire region. In reference to Borneo and Celebes the Sarasins [22] state that, as Celebes and Borneo do not present a single animal in common that is not found also in Java, Sumatra, or the Philippines, there is not the slightest possibility that a direct land bridge ever existed between Celebes and Borneo across the Macassar Strait since early Tertiary times. That there were indirect connections via the Sulu Archipelago, Mindanao, and the Sangi Islands to the north, and between Celebes and eastern Java by way of the Postilion and Paternoster islets, Bali and Lombok to the south, is entirely probable; in fact, almost certain.

I cannot accept Schuster's [23] general conclusions regarding the climate and vegetation of Pleistocene times in Java, nor his explanation of the geologic sequence of land connections in eastern Malaysia. Making due allowance for some manifestly erroneous identifications on his part,[24] I can see no reason for considering that, at the time the Trinil beds were formed, the low-altitude Javan climate was cooler than it is to-day. The altitudinal range of many of the species listed by him does not conform to their actual occurrence in nature; most of them, both in Java and in the Philippines (so far as they occur here), are low-altitude forms, even though some may exceptionally extend to and above an altitude of 1,200 meters. That in Pleistocene times the forests of Java were "typische Regenwälder der gemässigten Zone" positively cannot be accepted. His own

[22] Sarasin, P. und F., Materialen zur Naturgeschichte der Insel Celebes, III. Ueber die geologische Geschichte der Insel Celebes auf Grund der Thierverbreitung (1901).

[23] Schuster, J., Monographie der fossilen Flora der Pithecantropus-Schichten (1911) 1–70, *t. 1–27*. Reprint from Abhandl. Kgl. Bay. Akad. Wissensch. Math.-Phys. Klasse 25 [6] (1911).

[24] Thus, *Viburnum coriaceum*. While perhaps the correctness of the identification cannot be proved or disproved, the figure may just as well represent some species in any one of a half-dozen other genera in as many families.

list of species definitely shows that they were, like those of to-day, *typical low-altitude tropical forests.* I fail to see how the claim can be substantiated that, as a result of the cooling off in Pleistocene times, the vegetation was dislocated an entire height zone (approximately 800 meters). Incidentally, this would involve at most a change in the mean average annual temperature of but about 5° C., if we may judge Pleistocene weather conditions by modern ones in the Philippines and Java (see Table 2). It seems more probable, if there was any appreciable change in temperature at low altitudes in Java during Pleistocene times, that it was even less than is here indicated as the modern difference between the first and the second height zones. In temperate regions the difference in average temperature required to cause Pleistocene glaciation is estimated at but 6° C., but this difference in tropical regions would be relatively insignificant.

TABLE 2.—*Mean annual temperatures for various stations in the Netherlands East Indies, and the Philippines at sea level and at the approximate lower level of the second vegetation zone.*

	Altitude.	Mean annual temperature.
	m.	*°C.*
Batavia	8	26.03
Pasuruan	7.5	26.7
Manila	0	26.6
Los Baños	80	26.1
Glambock Selong	1,120	19.4
Bandoeng	730	22.2
Fort de Kock	920	21.0
Kajoemas	1,060	20.2
Mount Maquiling	740	21.4
Dansalan	701	22.8
Ganasi	735	23.7
Sumilao	740	23.5

Doctor Schuster, like others, disproves the existence of Wallace's Line, basing his refutation upon his interpretation of the paleobotanical evidence. He claims that Wallace's Line existed in Pleistocene times just as little as it does to-day. Schuster to the contrary notwithstanding, the botanical evidence, like the zoölogical, geological, and hydrographic evidence, indicates a definite distinction between eastern and western Malaysia. The principal part of the line of demarcation is the Macassar Strait, geologically the oldest part of Wallace's Line.

Doctor Schuster postulates successive waves of migration of Asiatic types to the east in Pliocene times, of which he differen-

tiates three, all starting in the Himalayan region, the first of which reached Australia, the second only as far as the Philippines and Celebes, while the third terminated in Java. These successive invasions necessitated corresponding land connections. In reverse order, the corresponding land bridges disappeared from east to west, and thus established more and more contracted limits to the spread of western elements. How illogical this explanation is can readily be seen in the westward distribution of Australian types of plants and animals. If the first break came east of Celebes we would logically expect to find about as many Australian types west of Celebes as we find in Celebes, for according to Schuster Celebes would then be connected with Asia As a matter of fact, Australian types of animals are practically absent in western Malaysia, while very few Australian types of plants are to be found here, in contrast to the considerable number of both found in Celebes, in eastern Malaysia as a whole, and in the Philippines. Barbour [25] notes that the supposed Papuasian element in the Javan fauna, which has been emphasized by Warner, is probably entirely nonexistent. He states that the fauna of Sumatra, Borneo, and Java has been entirely derived from the Malay Peninsula region. If Schuster be correct we would also expect to find in Celebes a considerable number of Dipterocarpaceae, proportionally as many as we have in the Philippines. Doctor Molengraaff's explanation of the geologic history of eastern Malaysia is more logical and more convincing than is that of Doctor Schuster.

From the data presented by Doctor Schuster my general conclusions would be that the low-altitude Pleistocene climatic conditions in Java were approximately identical with those existing to-day; that the forest flora represented in the Trinil beds was practically the same as the low-altitude tropical forests of western Malaysia as they exist to-day; and that, hence, these forests were definitely tropical ones and not at all of the temperate-zone type.

The most important fact brought out by Doctor Schuster is that the low-altitude Pleistocene Malaysian flora was practically identical with our modern one, indicating how very slow specific changes have been in Java, which is also true in the Philippines. The Javan Pleistocene fossil flora and the Luzon Pliocene fossil flora present only impressions that can absolutely be

[25] Op. cit. 165.

matched by living plants, the time element involved being several hundred thousand years. The Pliocene and Pleistocene Malaysian floras were not, then, radically different from the modern flora, being practically identical with that which exists to-day in the primary forests of Malaysia. Great changes in the floras of temperate regions are admitted for these epochs, but the equatorial region of Malaysia presents almost no changes, even in species. We may then consider that our present flora, that is, of the forested regions, is a Pliocene and Pleistocene one that has persisted with comparatively slight modifications. This involves the assumption that there were practically no changes in the general climatic conditions in the equatorial regions of Malaysia at low altitudes during the periods of great extension of the ice caps in the temperate zones, and this assumption is substantiated by the Pliocene and Pleistocene fossil marine faunas of both Java and the Philippines.

With this digression regarding the geologic history of the Malaysian region, we may now return to the subject of the geographic distribution of the dipterocarps and its bearing on the origin of the Philippine flora. The facts regarding their distribution have already been stated. The conclusion to be drawn from the paucity of forms in eastern Malaysia is perfectly evident. While the various forms could spread easily over the continental area comprising what is now southern Asia and the Sunda Islands, and to a very definite degree into the Philippines over the Sulu and Palawan bridges, they could not cross the narrow sea channels separating Borneo from eastern Malaysia. Only a few forms succeeded in reaching Celebes, the Moluccas, and New Guinea, and these by the roundabout routes over intermittent and always narrow connecting isthmuses from Mindanao to Celebes via the Sangi Islands, and to Gilolo and New Guinea via either Celebes or Talaut Island. Possibly a few came from Java through Bali, Lombok, and what are now the Postilion and Paternoster islets to southwestern Celebes.

In this connection it is of definite interest to examine Diels's recent paper on the Dipterocarpaceae of New Guinea.[26] He enumerates ten species in four genera for New Guinea; namely, *Anisoptera*, four; *Hopea*, three; *Shorea*, one; and *Vatica*, two. Of these *Hopea celebica* Burck is otherwise known from Celebes, and *Vatica papuana* Dyer from the Aru Islands, the others so

[26] Diels, L., Die Dipterocarpaceen von Papuasien, Engl. Bot. Jahrb. 57 (1922) 460–463.

far as known being confined to New Guinea. He states that the family plays an unimportant rôle in Papua and considers that there is no reason to believe that future investigations will greatly increase the number at present known.

He makes the significant statement that, while the species hitherto established are in part too imperfectly known to allow of positive systematization, those that are sufficiently well known stand in close relationship with species of Celebes and the Philippines; there are no apparent indications of independent form structure for the New Guinea species. He concludes that the Dipterocarpaceae represent a younger element in the New Guinea flora, an element which has been derived from the northwest by way of Celebes and the Philippines. This conclusion was reached by Doctor Diels solely on the indicated botanical relationships of the New Guinea species, and is absolutely in accord with the general conclusions I have drawn regarding the origin of the Philippine flora in relation to the geographic distribution of the Dipterocarpaceae. This apparent derivation of the Papuan Dipterocarpaceae from the northwest, that is, Celebes and the Philippines, may perhaps be interpreted as supporting the idea that in previous geologic epochs a drier climate characterized the lesser Sunda Islands, and perhaps southern Java, which would, of course, inhibit the eastern extension of hygrophytes over this southern route into Celebes. The only possible route under these conditions between western Malaysia and New Guinea would then be through Borneo, the Philippines, Celebes, and the Moluccas.

There are, of course, other than strictly geologic factors to be taken into consideration in discussing the differences between eastern and western Malaysia. As Mr. I. H. Burkill has recently indicated to me, there is the possibility that in past geologic epochs the climate of southern Java and of the lesser Sunda Islands may have been drier than it is to-day; even to-day the climate of Timor and of the lesser Sunda Islands generally is drier than that of other parts of Malaysia. This would have the effect of inhibiting the extension of the dipterocarps and of other plants, as well as animals, that are adapted to humid conditions eastward through the southern part of Malaysia, and this may in part explain the absence of dipterocarps in Timor and the lesser Sunda Islands. We must, however, not overlook the fact that there has also been much destruction of life on some of the smaller islands in this particular region by volcanic eruptions. The swift currents through such narrows as the Lombok

Passage would also greatly restrict the passage of both plants and animals, and it is safe to assume that such swift currents have existed since the Lombok Passage was formed.

In connection with the paucity of Dipterocarpaceae known from eastern Malaysia and the possibility that the number may be increased by further exploration, Diels has already expressed his opinion regarding New Guinea. No species is known from Gilolo, where a few at least are to be expected. Only five are known from all of Celebes, and in view of Doctor S. H. Koorders's extensive botanical explorations in northern Celebes (Minahassa) we can hardly expect many additional species in this part of Celebes. Doctor Koorders collected in Minahassa primarily as a forester for nearly five months, and as a forester he certainly would not have overlooked the economically important dipterocarps; his entire collection from Minahassa in northern Celebes, comprising some 3,500 numbers, presents only a single species of Dipterocarpaceae, *Shorea koordersii* Brandis. It would seem then that we are not justified in expecting numerous additions to the dipterocarp flora of eastern Malaysia as botanical exploration progresses, in spite of the fact that the flora of the entire region is very imperfectly known, although it is about as well known, comparatively speaking, as is that of Sumatra and Borneo.

We have seen then that the dipterocarps are very strongly represented in western Malaysia, that is, "Sunda Land," the Malay Peninsula, Sumatra, Java, and Borneo; very poorly represented in eastern Malaysia, Celebes, the Moluccas, Gilolo, and New Guinea; and fairly well represented in the Philippines, by nine genera and fifty species, the great trees of this family being dominant in the primary forests of our Archipelago at low altitudes. Therefore, it will be seen that the Philippines are intermediate between eastern and western Malaysia in dipterocarp representation.

What is the case in reference to other families of plants? It has been known for over twenty years that the Philippine flora presents strong Celebesian and Moluccan alliances, and as exploration has progressed Papuan, New Caledonian, and Australian elements have become more and more evident. At the same time, there are distinct evidences of definite relationships with western Malaysia or the Sunda Islands, as indicated by the genera of Dipterocarpaceae alone. Of the twelve genera of this family found in the Malay Peninsula and the Sunda Islands nine extend to the Philippines, as against four that extend to eastern

Malaysia. Of these nine *Isoptera* is known only from the Malay Peninsula, Bangka, Borneo, and Mindanao; *Parashorea* is known only from the Malay Peninsula, Sumatra, Borneo, and the Philippines (Luzon to Mindanao); and *Pentacme* is known only from the Malay Peninsula and the Philippines (Luzon to Mindanao).

It has long been known that there are striking differences between the floras of eastern and western Malaysia, but it seems that as yet no botanist has made a direct comparison to see wherein the differences lie. The number of species is so great (estimated by me at 45,000 for the entire region, including the Philippines) that I have been obliged to limit my investigations to a larger unit and have selected the genus as the unit. This task has been sufficiently arduous, for the number of genera involved is approximately 3,000.

In comparing the ranges of all genera of flowering plants known from the Malaysian region as between eastern and western Malaysia and the Philippines, eliminating those introduced by man in modern times, we note the following significant results: In western Malaysia we find about three hundred fifty-six genera which are not known from east of Wallace's Line, *but in the Philippines two hundred eighteen, or 61 per cent, of these occur.* In eastern Malaysia we find about two hundred twenty-five genera which do not extend to western Malaysia, *and of these fifty-six, or about 25 per cent, are known from the Philippines.*

We have then in the Philippines numerous genera from western Malaysia that do not occur in eastern Malaysia, and fewer, but at the same time a most striking assemblage, of Celebesian, Moluccan, Papuan, and Australian types that extend to the Philippines but do not reach western Malaysia. There are Australian types in western Malaysia, but few indeed as compared with the same element in the Philippine flora. In general, then, the generic distribution in Malaysia confirms the conclusions that may be drawn from the study of the distribution of the Dipterocarpaceae, namely: That there were certain definite land connections between Borneo and the Philippines over which the western Malaysian elements migrated into the Philippines, including our Dipterocarpaceae, numerous genera of wide Malaysian distribution, and the two hundred eighteen genera that occur in western Malaysia and the Philippines but not in eastern Malaysia. Later these connections were broken, between Mindoro and the Calamian Islands to the north and in the Sulu Archipelago to the south, inhibiting further Bornean migrations into the Archipelago proper but permitting later

Bornean elements to enter the Balabac-Palawan-Calamian group to the north and the Sulu Archipelago and perhaps the Zamboanga Peninsula of Mindanao to the south. It is significant that the ornithologists and zoölogists wish to derive the Palawan avifauna and mammalian fauna wholly or largely from Borneo, and the herpetologists and some entomologists are apparently like minded in reference to their respective groups. Everett[27] claims that there has been no land connection between the Palawan-Calamian group and the Philippines proper since Palawan received its present fauna. Pagenstecher,[28] however, states that, of the two hundred thirty-five species of Lepidoptera that occur in Palawan, one hundred thirty are found in the Philippines proper and one hundred twenty in Borneo, and sixty-five are common to the three regions. In respect to the lepidopterous fauna Palawan is evidently as much Philippine as it is Bornean. The Palawan flora is definitely about as much Philippine as it is Bornean, and the Bornean elements in its flora are relatively very weak when compared with the manifestly very strong Bornean zoölogical elements found there.

We have already seen that direct land connections between Borneo and Celebes have not existed since early Tertiary. There were probably indirect connections via eastern Java and Celebes through what are now intervening islands, but these connections could not have been very extensive nor very long continued. There were definite connections between Mindanao and Celebes via the Sangi Islands, and possibly between Mindanao and Gilolo and, in turn, with New Guinea via Talaut Island, and these connections existed some time during the Tertiary; probably they existed at different times, having been more or less intermittent, for depressions and elevations have been characteristic of the entire region throughout the Tertiary and Quarternary ages. The Celebes-Mindanao connections were not necessarily in existence at the same time that a land bridge existed between Borneo and Mindanao. The evidence seems to be that the connections between the Philippines and Borneo were earlier, more extensive, and longer continued than were the connections between Mindanao and the islands to the south and east. Thus the dominant dipterocarps were permitted to enter

[27] Everett, A. H., Remarks on the zoögeographical relationships of the island of Palawan and some adjacent islands, Proc. Zool. Soc. London (1889) 220–228, map.

[28] Pagenstecher, A., Die geographische Verbreitung der Schmetterlinge (1909) 1–451 (p. 237).

the Philippines, some with and some after (see p. 8) the arrival of numerous other western Malaysian types; at certain times a limited number of Philippine types of dipterocarps and other groups were enabled to migrate southward into Celebes, Gilolo, the Moluccas, and New Guinea; and at the same time numerous generic types from these regions, together with a rather strong Australian element, were enabled to reach the Philippines.

The explanation of the fundamental differences in the geologic history of eastern and western Malaysia, so clearly stated by Molengraaff, enables us to give the reasons for the evident differences between the floras and faunas of these two regions, and to explain why the Philippine flora and fauna show definite relationships with those of both eastern and western Malaysia; why the Australian element is so much stronger in the Philippine flora than it is in that of western Malaysia; and why the dipterocarps and numerous other Malaysian types and, in general, the Australian elements failed to reach Formosa, although many of them extend to northern Luzon and some even into the Babuyan and Batan Islands. Formosa is separated from the Philippines by a very deep channel or trough, similar to those discussed by Molengraaff as characteristic of eastern Malaysia. There is no evidence of land connection between Luzon and Formosa since early Tertiary times.

I have already stated (p. 25) that the zoölogists generally derive the Palawan-Calamian fauna from Borneo, some claiming that no connection can have existed between this group and the Philippines proper since Palawan received its present fauna. It is of some interest here to examine the Philippine distribution of our dipterocarps. The larger islands characterized by the presence of numerous species are Luzon, Mindoro, Samar, Leyte, Negros, Panay, Mindanao, and Balabac. But four species are known from the Balabac-Palawan-Calamian group and but one from the Sulu Archipelago. Thirty-nine of our fifty known species, or 78 per cent, are endemic, the remainder occurring in various parts of western Malaysia. Most of our endemic as well as our extra-Philippine forms are of wide distribution within the Archipelago, extending from northern Luzon to Mindanao and Basilan. These are, of course, some local species.

Of our nonendemic dipterocarps *Dipterocarpus gracilis* Blume is recorded from Luzon, Mindoro, and Java; *D. grandiflorus* Blanco, from Luzon to Mindanao, Palawan, Borneo, Bangka, and the Malay Peninsula; *D. hasseltii* Blume, from Luzon to

Mindanao, Java, Sumatra, and the Malay Peninsula; *D. trinervis* Blume, from Palawan and Java; *Anisoptera curtisii* Dyer, from Luzon to Negros, Borneo, and the Malay Peninsula; *Hopea pierrei* Hance, from Luzon to Mindanao, Borneo, Malay Peninsula, and Indo-China; *Shorea balangeran* Dyer, from Luzon to Mindanao, Borneo, Bangka, and Billiton; *S. eximia* Scheff., from Luzon to Mindanao, Borneo, Sumatra, and the Malay Peninsula; *S. palosapis* Merr., from Luzon to Mindanao and Borneo; *S. teysmanniana* Dyer, from Luzon to Mindanao and Bangka; and *Isoptera borneensis* Scheff., from the Zamboanga Peninsula of Mindanao, Borneo, Bangka, and the Malay Peninsula.

Only one dipterocarp, a species of *Hopea*, is known from the Sulu Archipelago, this occurring on Tawitawi Island. This might be interpreted to mean that our dipterocarps could not have come over the Sulu bridge. There are a few islands in the Sulu Archipelago on which dipterocarps might be expected, notably Jolo and Tawitawi, but on Jolo the primary forest has practically all been destroyed by man. The Sulu Archipelago has moreover been raised and depressed, not once but several times, so that it is only reasonable to suppose that its vegetation has at times been partly or entirely destroyed by natural causes.

In Palawan we find but five recorded species of dipterocarps, although future exploration may increase this number. They are *Dipterocarpus vernicifluus* Blanco, *D. grandiflorus* Blanco, *D. trinervis* Blume, *Vatica obtusifolia* Elm., and *V. blancoana* Elm. Of these the first two occur throughout the Philippines from northern Luzon to Mindanao, the first being supposedly endemic, although possibly it should be reduced to *D. gracilis* Blume, of Java; the second extends to Borneo, Bangka, and the Malay Peninsula. *Dipterocarpus trinervis* Blume is known only from Palawan and Java; *Vatica blancoana* Elm., only from Palawan and Mindanao; and *V. obtusifolia* Elm. is confined to Palawan. In Palawan we know of no representatives of the genera *Anisoptera, Balanocarpus, Hopea, Isoptera, Parashorea, Pentacme,* and *Shorea;* yet, all occur in the Philippines, many being dominant, and all occur in western Malaysia. Can, then, our dipterocarps have come in over the Palawan bridge? The question cannot be answered definitely, but it is very clear that most of our forms must have come in over one or both of these Borneo-Philippine bridges, the Sulu to the south and the Palawan to the north, on account of their paucity in the islands to the south of the Philippines and in Java; they could scarcely have come in from Java via Celebes. It is possible, even probable,

that Palawan has been submerged and most or all of its vegetation destroyed since the existence of its earlier connection with the Philippines by which our dipterocarps and numerous other western Malaysian types in all probability reached the Philippines (see p. 8); whatever the case, the Palawan-Calamian group has been severed from the Philippines proper by the Mindoro Strait since Pleistocene times, and received much of its present fauna from Borneo in the middle or late Pleistocene. At the same time it has also received certain very definite Bornean elements of its flora that have failed to reach the Philippines proper, although its flora is by no means strictly Bornean, but presents approximately as many Philippine elements as it does Bornean ones. In other words, its flora has been derived in part from Borneo and in part from the Philippines proper.

There must have been extensive and especially prolonged connections between Borneo and the Philippines, but there is no evidence that these connections were more than the Sulu and Palawan isthmuses. It is highly improbable, although not impossible, that some of our western Malaysian elements came in from eastern Java over the Java-Celebes and the Celebes-Mindanao bridges; but, had there been any extensive migrations over this route, we would naturally expect to find a much greater mingling of Australian and Asiatic types in Celebes than actually exists, with corresponding Australian types in Java. In the Mindoro flora we find certain western Malaysian types that extend from Borneo through Palawan to Mindoro but do not occur farther east. We cannot ignore the fact that our one large indigenous mammal, the timarao, is confined to Mindoro, and that it must have been derived from Asiatic stock; it unquestionably reached Mindoro over the Palawan bridge. It is currently stated that the timarao is most closely allied to the anoa of Celebes, but this seems not to be the case, as Doctor Hollister informs me that the timarao is not congeneric with the anoa but is congeneric with a form that occurs in Borneo.

CONCLUSIONS

1. From the geologic and hydrographic data so admirably presented by Molengraaff, it is perfectly evident that the geologic history of eastern Malaysia has been radically different from that of western Malaysia. The area approximately delimited by the Asiatic continental shelf, which carries upon it all of the Sunda Islands, was a continental area in the Pleistocene and probably

at times during the preceding geologic periods; similarly, the area delimited by the Australian continental shelf, carrying upon it New Guinea, was also a continental area. Interposed between these two stable continental regions, that is, from the Lombok Passage and the Macassar Strait extending to the eastward as far as the west end of New Guinea and northward through most of the Philippine Archipelago, we find a region in sharp contrast to the two above-mentioned stable continental areas. The entire intermediate region has been unstable, subject to elevations and depressions, from at least the early Pleistocene to the Recent and is still orogenetically active and, as a result, still unstable. In other words, archipelagic rather than continental conditions have persisted in this vast region since the early Pleistocene, and probably earlier.

2. Wallace's Line, so named by Huxley, separating the fauna of eastern and western Malaysia, was located by Wallace through the Macassar Strait and extended southward through the Lombok Passage between Bali and Lombok. It is essentially the western boundary of the insular unstable area and, as a corollary, the eastern boundary of the ancient stable continental area. Wallace's Line is a striking faunal and floral boundary (although not an absolutely separating one) when the distribution of all groups of animals and plants is taken into consideration. It is essentially based on fundamental geologic differences between Sunda Land and the region to the east. West of Wallace's Line animals and plants have been able to migrate from one part of the previously existing continental area to other parts, subject only to those limitations that are found in continental areas. East of this line all intermigrations of Australian and Asiatic types of animals and plants have been interrupted by the constant archipelagic conditions existing in the region under discussion and, at times, all or most intermigrations have been inhibited by impassable barriers in the form of separating arms of the sea. As between the various islands in this vast region and the previously existing continental areas to the west and southeast, land connections have never been more than narrow isthmuses. The evidence is that this fundamental dividing line between eastern and western Malaysia did not extend to the east between Celebes and Mindanao, as originally placed by Wallace, but extended northward through the Sibutu Passage and the Sulu Sea to the Mindoro Strait and thence northward and then eastward into the Pacific Ocean between Formosa and the Batan Islands. There have been no direct land connections between

Celebes and Borneo across the Macassar Strait since the early Tertiary, but indirect connections have existed through Borneo and Celebes via the Sulu Archipelago, Mindanao, and the Sangi Islands, and probably also between eastern Java, Bali, Lombok, and other smaller islands and southwestern Celebes. The southward extension of Wallace's Line through the Lombok Passage, as well as its northern extension through the Sibutu Passage, the Sulu Sea, and the Mindoro Strait has not been as strongly marked nor as persistent as the Macassar Strait, and hence has not been as efficient a barrier to the passage of animals and plants as has the narrow strait between Celebes and Borneo.

3. Weber's Line, so named by Pelseneer, is apparently the approximate eastern boundary of the unstable area, separating the insular region from the continental and stable areas now delimited by the continental shelf surrounding and uniting New Guinea and Australia. Geologically, this is ranked by Molengraaff as the most important dividing line in Malaysia. Biologically, it apparently ranks with Wallace's Line as an important dividing line between the Moluccan-Timor regions and Australia, quite as Wallace's Line separates western from eastern Malaysia. This paper then is essentially a re-interpretation of Wallace's Line, botanically tested, as well as a test of Weber's Line.

4. The Dipterocarpaceae present eleven genera and one hundred thirty-five species in the Eastern Peninsula, eleven genera and one hundred forty-four species in the Sunda Islands, nine genera and fifty species in the Philippines, and only four genera and fourteen species in the entire group from Celebes to New Guinea southward to Lombok and Timor. A study of the Malaysian distribution of all the Malaysian genera of flowering plants shows about three hundred fifty-six genera in western Malaysia that are unrecorded from eastern Malaysia, of which two hundred eighteen, or 61 per cent, reach the Philippines; and about two hundred twenty-five genera in eastern Malaysia that do not reach western Malaysia, of which fifty-six, or about 25 per cent, reach the Philippines. The Philippine flora thus presents strong relationships with the floras of both Papua and Sunda Land. The evidence from the geographic distribution of the Dipterocarpaceae conforms entirely with the general generic distribution of all groups of flowering plants in the whole Malaysian region, indicating previously existing and rather long continued land connection between the Philippines and Borneo via the Sulu Archipelago to the south and the

Balabac-Palawan-Calamian group to the north. This connection was apparently earlier, more pronounced, and longer continued than the connections between Mindanao and Celebes, Gilolo, the Moluccas, and New Guinea to the south and east.

5. The dipterocarps were apparently dominant in the Philippines as early as the Pliocene, and probably earlier. From the biologic characters of the group it is evident that when they reached the Philippines the entire region was a forested one.

6. After the earlier connections with Borneo were broken there were later definite connections between Borneo and, apparently, the Zamboanga Peninsula (southwestern Mindanao was during a portion of Pleistocene time a separate island) via the Sulu group to the south, and between the Balabac-Palawan-Calamian group to the north as far as the Mindoro Strait, allowing later definite migrations into these regions of Bornean types of animals and plants which could not reach the Philippines proper.

7. The intermittent isthmuses connecting Mindanao with the islands to the south and southeast have permitted intermigrations here, and Celebesian, Moluccan, Papuan, and a distinctly important series of Australian types have thus traveled the longer distance, many to northern Luzon and even into the Babuyan Islands, rather than the shorter distance into western Malaysia, not having been able to cross the narrow but long-persistent Macassar Strait.

8. The entire absence of the dipterocarps in Formosa, the slight evidences of biological relationships between Luzon and Formosa, and the fact that, with very few exceptions, none of the Australian and eastern Malaysian types in the Philippine flora reach Formosa indicate clearly that there have been no land connections here since early Tertiary times.

9. The distribution of birds, reptiles, fresh-water fishes, mammals, and many groups of insects as between eastern and western Malaysia in general conforms to the distribution of the plants. Thus, very many Asiatic types extend as far as the Macassar Strait and, while some cross it, they appear in rapidly dwindling numbers as we go eastward to New Guinea. Likewise, Australian types decrease with as great or greater rapidity as we go westward from New Guinea. In the Philippines we find distinct alliances in the mammals and birds with both eastern and western Malaysia, corresponding to similar alliances in the flora. This likewise holds true for the reptiles and insects, while of the fresh-water cyprinoids twenty-seven

are known from the Philippines, in contrast to one or, at most, two that occur east of Wallace's Line and live only in Lombok and Sumbawa, again indicating more-pronounced and longer-continued land connections with the islands to the southwest than with those to the south and southeast.

10. No single line can be drawn, anywhere in Malaysia, that is a true biogeographic boundary. With two stable areas delimited by the Asiatic and Australian continental shelves and an intermediate insular unstable region between these two stable areas there must of necessity be an eastern and a western boundary of the unstable area where it impinges on the stable areas to the east and to the west. The western limits of the unstable area are approximately defined by Wallace's Line, and the eastern limits by Weber's Line. These two biogeographic boundaries are primarily due to fundamental geologic conditions. They may have approximately equal values but a much more intensive biologic exploration of the entire region will be required before the essential data necessary to evaluate them become available. Wallace's Line cannot be abandoned in favor of Weber's Line nor vice versa.

11. In Malaysia as a whole we find apparently two great centers of origin and distribution, Sunda Land to the west and, as Miss Gibbs [29] has already pointed out, New Guinea to the east. To a large degree the fauna and flora of the islands in the intermediate unstable area between Wallace's and Weber's Lines are made up of infiltrations from the regions to the west and to the east. From both regions there have been strong migrations into the Philippines, one through the Sulu and Palawan bridges from Sunda Land via Borneo, the other from Papua through the Moluccas and Celebes.

[29] Gibbs, L. S., Dutch N. W. New Guinea. A contribution to the phytogeography and flora of the Arfak Mountains (1917) 1–126 (p. 39).

ILLUSTRATIONS

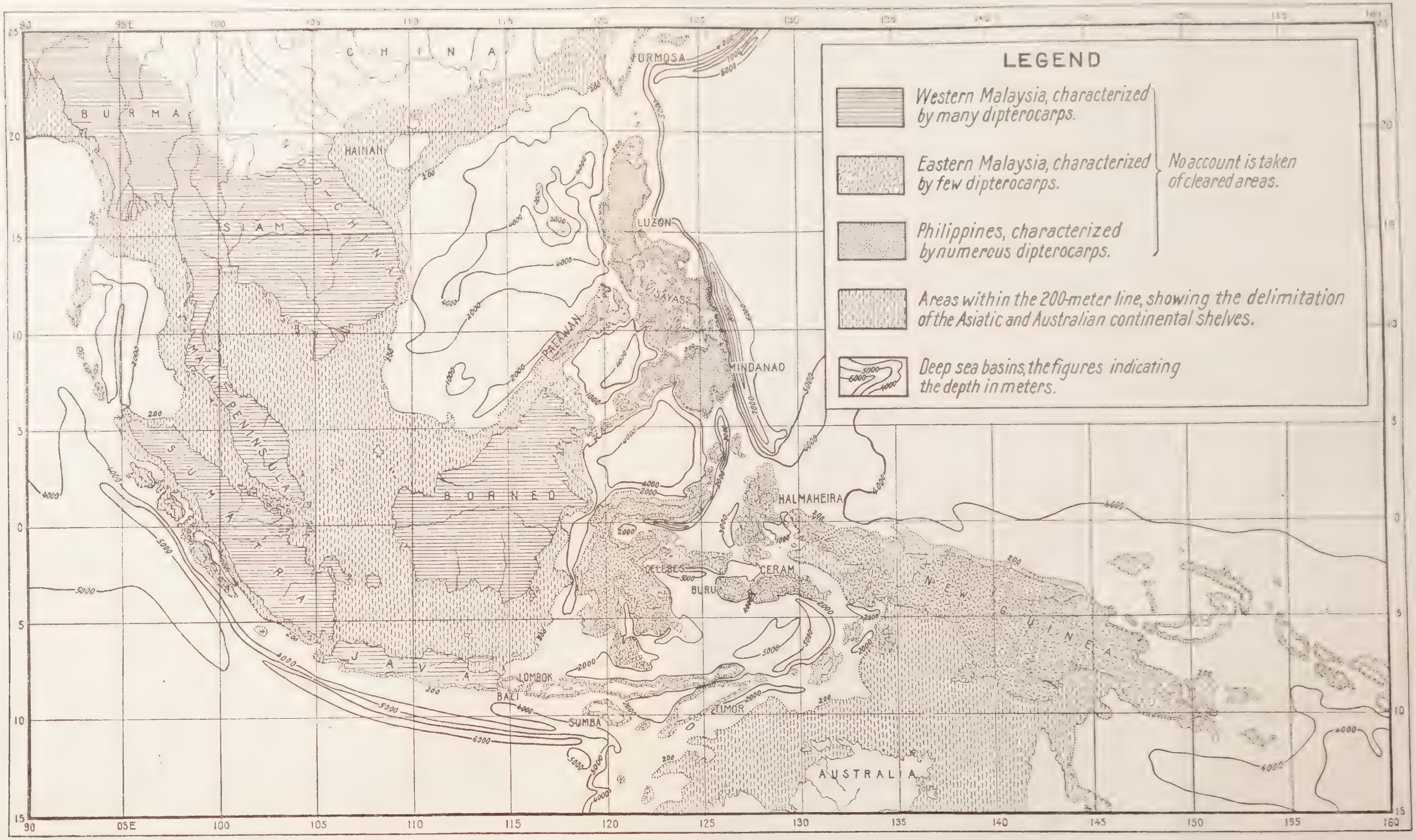

PLATE 1. THE MALAYSIAN REGION, SHOWING THE ASIATIC AND AUSTRALIAN CONTINENTAL SHELVES AND THE ASSOCIATED DEEPS.

PLATE 2. THE UNSTABLE AREA BETWEEN THE SUNDA ISLANDS AND AUSTRALIA, SHOWING THE POSITIONS OF WALLACE'S AND WEBER'S LINES.

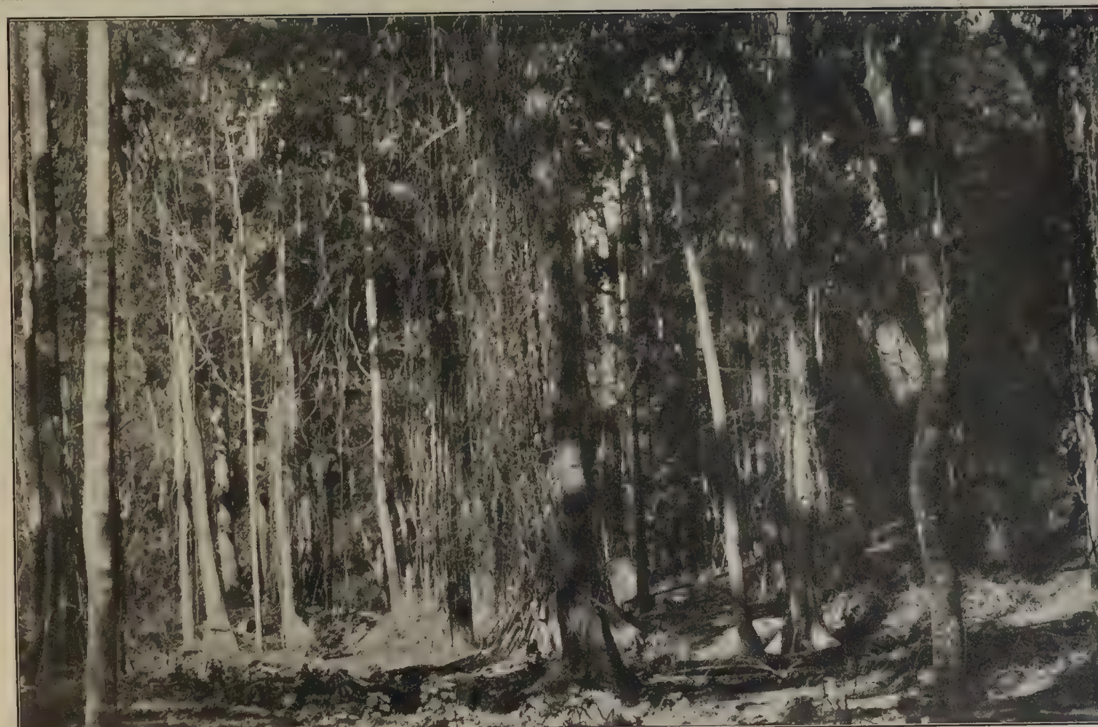

PLATE 3.

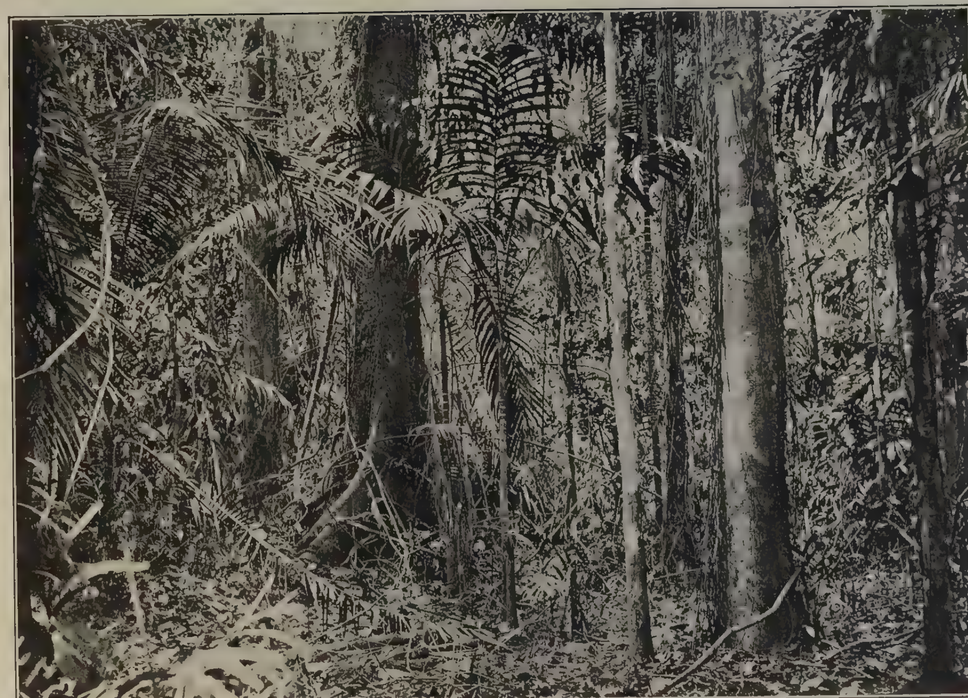

PLATE 4.

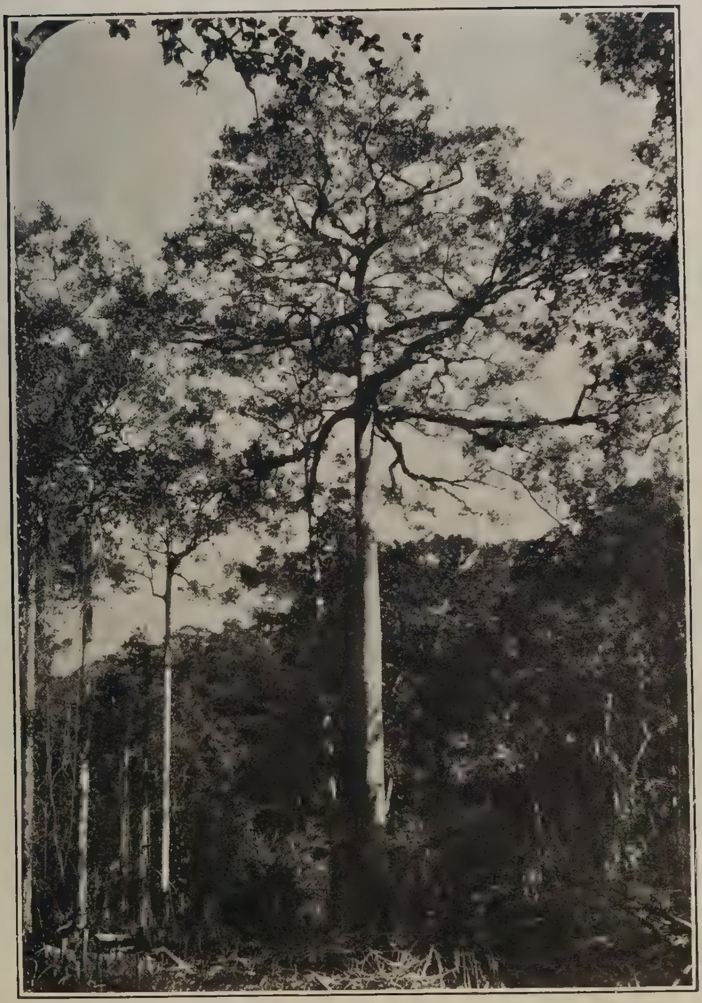

PLATE 5.

PLATE 6.

PLATE 7.

Fig. 1.

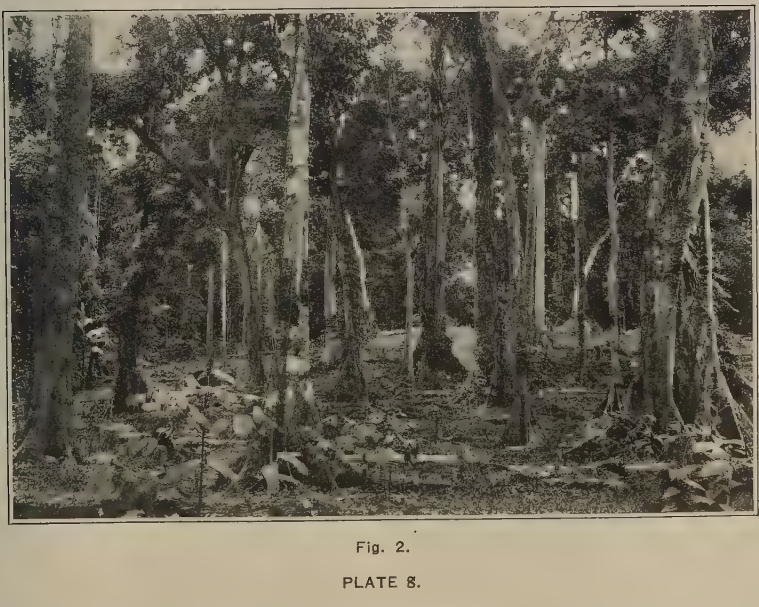

Fig. 2.

PLATE 8.

OBSERVATIONS ON THE LIFE HISTORY OF THE HORSE OXYURID (OXYURIS EQUI)

By Benjamin Schwartz
Of the University of the Philippines

ONE PLATE AND TWO TEXT FIGURES

SCOPE OF WORK

The object of this paper is to record observations that have a bearing on the life history of *Oxyuris equi*, a nematode of common occurrence in the colon, cæcum, and rectum of horses in the Philippine Islands. In view of the fact that several references to the morphology and biology of *Oxyuris equi* are not obtainable in the Philippine Islands the work of former investigators that may have a bearing on the life history of this parasite cannot be reviewed fully in this paper.

THE EGG

The egg of *Oxyuris equi* is elliptical in shape, slightly asymmetrical, and is enveloped in a firm cuticle having a double contour and also an operculum at one end, the latter resembling that of trematode eggs. Numerous observations on the hatching of the eggs in vitro have shown that the larva invariably escapes from the eggshell through the opening that is covered by the operculum. Empty eggshells that were recovered from the intestines of guinea pigs that were fed eggs of *Oxyuris equi* almost invariably lacked the operculum. In eggs that hatched in vitro the operculum frequently adhered to the eggshell and in several cases still retained its normal position. Such shells were intact, however, showing conclusively that the larvæ must have escaped through the opercular end and that the operculum, after being lifted as a result of the movements of the embryo against its inner surface, regained its normal position following emergence of the larva from the shell.

Measurements of numerous eggs have shown considerable variation in size, the range of variation being from about 74 to 100 μ in length by from 38 to 47 μ in width. In Table 1 are given the records of size of twenty-three eggs selected at random.

TABLE 1.—*Showing variation in size of eggs of Oxyuris equi.*

Egg No.	Length.	Width.	Egg No.	Length.	Width.
	μ	μ		μ	μ
1	82	41	13	84	46
2	95	42	14	91	46
3	89	44	15	73	40
4	88	46	16	91	38
5	84	42	17	91	38
6	91	46	18	76	42
7	86	46	19	89	46
8	99	46	20	91	46
9	91	46	21	85	40
10	87	46	22	91	42
11	91	42	23	91	46
12	89	40			

Eggs considerably smaller than those recorded in Table 1 are occasionally found, but they are rare and probably abnormal since no miniature embryonated eggs have been observed in any of my cultures.

OVIPOSITION

Oviposition has been repeatedly observed in vitro, and in many cases certain specimens that were kept overnight in the laboratory in beakers containing physiological salt solution yielded many eggs that were found floating on the surface of the liquid, the eggs being agglutinated by a gluey substance that is insoluble in water and in physiological salt solution (fig. 1).

So far as my observations go, long-tailed forms of *Oxyuris equi* (*mastigoides* type) almost invariably oviposit in vitro, discharging practically the entire egg content, whereas short-tailed forms (*curvula* type) seldom oviposit under similar conditions; but few eggs are discharged from these ovipositing forms, the bulk of the eggs being retained in the uteri. In this connection it may be mentioned that long-tailed forms of *Oxyuris equi* are comparatively scarce in native horses and that they are usually located in the cæcum, whereas short-tailed forms are usually located in the colon, in which organ they were frequently found in large numbers (fig. 2).

Oviposition in *Oxyuris equi* is preceded by prolonged contractions of the uterus whose movements may be characterized as peristaltic. Uterine contractions are practically the only evidence of vitality of horse oxyurids, since I have never observed the characteristic nematoid movements in these parasites, and

according to my experience they cannot be artificially stimulated to activity by heat. The worms appear rigid and without any visible sign of activity, except occasional feeble movements of the tail, not only after they have been removed from the host but also when they are encountered in their normal location within a short time after the death of the host animal. Other intestinal as well as a stomach-inhabiting nematode removed at the same time from the host exhibited the usual lively nematoid movements of contraction, expansion, and of twisting

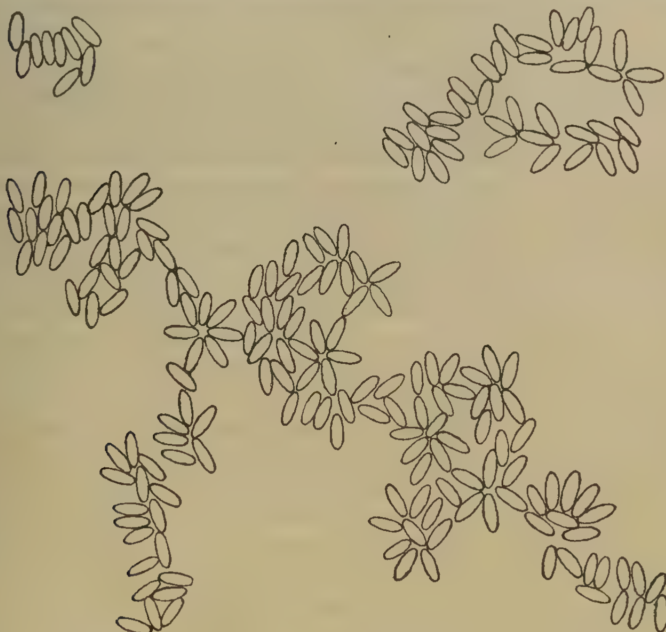

FIG. 1. Agglutinated eggs of *Oxyuris equi*. Free-hand sketch from cover-glass preparation.

the body into various positions. The only test of the vitality of *Oxyuris equi* is close examination of the worms for evidence of uterine movements, which are visible to the naked eye because the internal organs can be seem through the transparent cuticle.

During the uterine contractions the eggs are pushed forward and backward with the wavelike movements of the uterus and this process may continue for several hours before oviposition takes place. The eggs are usually liberated with considerable force, often with explosive violence, and stream out through the vaginal opening in stringy masses which flatten out in thin

layers on the surface of the fluid medium, where they remain floating like frog spawn. The gluey invisible substance that holds the eggs together does not deteriorate after prolonged exposure to air. In view of this gluey investment, the eggs adhere tenaciously to any object with which they come in contact. If the vessel, containing eggs on the surface of a liquid medium, is tilted the eggs adhere to its sides and cannot be washed off or pried loose by violent agitation of the contents of the vessel. When sucked up in a glass pipette or stirred with a glass rod the eggs adhere to the surface of the glass with equal tenacity. In liquid media normally oviposited eggs float, and only isolated eggs sink to the bottom.

FIG. 2. *a*, *Oxyuris equi* (*curvula* type), short-tailed female; *b*, *Oxyuris equi* (*mastigoides* type), long-tailed female. Natural size.

Following the discharge of eggs from the uterus, the females of *Oxyuris equi* shrink in size, the cuticle becomes wrinkled in consequence of the shrinkage, and the worms exhibit no further signs of vitality. Egg laying thus appears to be the last function performed by the females of *Oxyuris equi*, death probably ensuing after the act of oviposition has been completed. Although this conclusion is based upon observations in vitro, it is highly probable that the same course of events ensues under conditions that are normal for this parasite, because adult females of *Oxyuris equi* are always full of eggs, indicating that they discharge their eggs all at once; possibly they may oviposit several times in rapid succession, and those that have discharged their eggs may be rapidly eliminated from the digestive tract. The scarcity or even total absence of males in hosts harboring numerous females of *Oxyuris equi* warrants the view that the discharge of the sexual elements is the final function in the life of the males, the latter probably passing out of the host shortly after copulation.

Numerous attempts were made to induce the discharge of eggs by short-tailed females, but these attempts were only partially successful, resulting either in the liberation of few eggs or in a sudden eversion of the uteri and liberation of the eggs with explosive violence. This occurred in water and in phy-

siological salt solution. The following artificial stimuli were used to bring about oviposition in vitro. The water or salt-solution medium was acidulated and rendered slightly alkaline; the medium was gradually heated by addition of hot liquids (hot water and hot physiological salt solution being added to the respective media); the worms were transferred from water to salt solution and vice versa; the worms were transferred suddenly from a cold medium to a warm medium. The results obtained in these attempts were as follows:

Specimens that exhibited no uterine movements could not be stimulated to uterine contractions by any method; these forms were probably nonviable. Females that exhibited uterine contractions generally reacted positively to artificial stimuli. As a result of transferring the worms from water to salt solution and vice versa, the uterine contractions were generally accelerated. Gradually heating the medium in which the worms were contained and the sudden transfer of the worms from a cold to a warm medium had a very marked influence on the movements of the uterus which became intensified; these intense contractions continued after the liquid had cooled and resulted in an explosive discharge of eggs with eversion of the uterus through the vaginal opening.

Several years ago I made similar observations on oviposition in a species of *Oxyuris* from a chimpanzee from the National Zoölogical Park at Washington, D. C. Numerous specimens, all females, were obtained from the monkey following the administration of an enema. The parasites were alive and when viewed through a binocular microscope marked movements of the uteri were observed, these movements terminating with the discharge of stringy masses of eggs. In a second lot of worms obtained from the same monkey, the parasites were transferred to warm physiological salt solution, which resulted in rapid liberation of the eggs. Following the expulsion of the eggs the worms became quiescent.

Seurat(8) records similar observations on egg laying in a species of oxyurid in which oviposition was preceded by uterine contractions which resulted in the liberation of the eggs in long strings.

DEVELOPMENT OF EGGS

The usual procedure that is followed in order to obtain large numbers of eggs of a given species of nematode for life-history studies consists in securing mature females and chopping them

up finely with a pair of scissors, thus liberating the eggs, which may be planted on a charcoal and fæces mixture, in water, or in any other suitable medium. This procedure was found to be inapplicable to *Oxyuris equi*, because numerous attempts to bring about the development of the eggs of this parasite by planting artificially liberated eggs in water, in physiological salt solution, on charcoal and fæces mixtures, in 2 per cent as well as in weaker dilutions of formalin, were invariably unsuccessful. The eggs underwent degenerative changes in all media except formalin solution, in which liquid they remained intact for some time.

Artificially liberated eggs of *Oxyuris equi*, secured as a result of chopping up the worms, differ from normally discharged eggs in that the egg substance has a finely granular appearance, fills almost completely the interior of the shell, and shows no trace of segmentation. In the opercular end of these eggs one or two spherical areas less dense than the remaining egg substance are present (Plate 1, fig. 1). In eggs that are discharged from the uterus the egg substance appears as a compact coarsely granular mass, more or less spherical in shape, and filling only the central portion of the interior of the shell, leaving empty spaces at both poles. Moreover, the egg substance shows decided segmentation (Plate 1, fig. 2).

In a number of cases I examined eggs shortly after they were oviposited following the application of artificial stimuli and found them to be segmented, thus showing that segmentation occurs rapidly, probably while the eggs are still in the uterus.

The failure of eggs, artificially liberated by chopping up female oxyurids, to develop and the rapidity with which oviposited eggs develop in vitro indicate that some profound change occurs in the eggs shortly before they are laid. Whether this change is that of fertilization, or whether it is due to the early cleavage stages that probably occur before oviposition, has not been determined.

Another respect in which artificially liberated eggs differ from those that are normally expelled by the female parasites is that the former sink to the bottom of liquid containers in one solid mass that can be broken up only with considerable difficulty, owing to their being firmly agglutinated. When broken up into small thin masses the latter may come to the surface. Normally discharged eggs float almost invariably on the surface of water and salt solution. Some eggs that are liberated from short-tailed females, as a result of the application of arti-

ficial stimuli that are described elsewhere in this paper, are segmented and develop normally, whereas others are nonsegmented and deteriorate. Eggs that are liberated under such conditions in large masses due to the eversion of the uterus are largely nonsegmented and do not show any developmental changes in vitro. Eggs that are normally deposited by short-tailed females develop normally.

Development of the eggs proceeds rapidly on the surface of liquid media and it takes place just as rapidly if the eggs are placed on dry glass slides and not protected in any way from loss of moisture content. Development also proceeds normally in eggs that adhere to the sides of glass beakers at a considerable distance above the surface of liquid media.

In view of the gluey investment of the eggs they retain a somewhat moist appearance for several days even though they are kept in a dry place and continue their normal development. The gluey coating probably makes possible the retention of sufficient moisture for development. No differences in the rapidity of development of eggs kept in dry and moist media, respectively, have been observed; therefore, it may be concluded that environmental moisture is not an essential factor in the development of eggs of *Oxyuris equi,* the necessary moisture being contained in the egg and protected against evaporation by the gluey substance that surrounds it.

While free access of moisture does not appear a necessary environmental factor in the development of the eggs of *Oxyuris equi,* free access of oxygen is essential, since development was not observed in eggs that sank to the bottom of liquid-containing vessels. In glass beakers, containing floating eggs on the surface of water or physiological salt solution, numerous isolated eggs were usually found at the bottom, and these eggs after many days showed no developmental changes beyond those shown in Plate 1, figs. 2 and 3. Meanwhile the eggs floating on the surface developed rapidly and in four days contained active embryos. That nondeveloping eggs at the bottom of liquid-containing vessels were viable and capable of complete development was shown by the fact that when these eggs were transferred to glass slides, and the moisture was allowed to evaporate, they continued their development and attained the embryonated stage. Furthermore, when the liquid in glass dishes containing nondeveloping eggs at the bottom was allowed to evaporate, development was resumed as soon as the eggs were exposed to oxygen, and motile embryos were formed. It is evident, there-

fore, that oxygen is an essential factor in the development of the egg of *Oxyuris equi.*

Within from twenty-four to thirty-six hours after oviposition individual blastomeres could be made out only with difficulty, and in many instances could no longer be distinguished, because the outline of the embryo became evident (Plate 1, fig. 4). Within from forty-eight to sixty hours after oviposition development had proceeded to the stages shown in Plate 1, figs. 5 and 6. The embryos showed a definite orientation in the shell, the knoblike constricted portion being located at the opercular end. Cultures of eggs seventy-two hours old showed a sausage-shaped embryo (Plate 1, fig. 7) which exhibited sluggish movements. Ninety-six-hour cultures showed embryonated eggs, the embryos exhibiting lively and continuous movements within the shells.

LONGEVITY OF EMBRYONATED EGGS

Although the eggs of *Oxyuris equi* offer considerable resistance to lack of moisture and to absence of oxygen, and although the embryonated eggs retain their vitality for some time even though they are kept dry until the egg masses lose their glistening appearance, prolonged subjection of the eggs to unfavorable conditions results in their gradual loss of vitality and, ultimately, in death. Newly formed embryos were active within the shell despite the fact that they were kept in a dry place. After several days' drying the embryos were inactive in the shell but resumed their activities rapidly when moistened. At this stage hatching readily occurred in vitro. After two or three weeks' drying the larvæ appeared sluggish when moistened, and many showed no movement within the shell. Such eggs were still viable, because when they were fed to guinea pigs they hatched in the small intestine. Embryonated eggs that were kept dry on slides for about six weeks appeared wrinkled within their shells and, although but few had undergone pronounced degeneration, the intact forms showed no movement when moistened, were paler in appearance than normal larvæ, and failed to respond to heat stimulation. Larvæ kept in a moist beaker for a similar period showed more-pronounced symptoms of degeneration. It is thus evident that the embryonated eggs of *Oxyuris equi,* though resistant to unfavorable conditions for a short time after the formation of the embryo, succumb to environmental conditions after several weeks.

HATCHING

Hatching was observed in vitro in eggs five days after oviposition and one day after the actively motile embryonated stage had been reached. As has already been stated, the embryos escape through the opening in the shell that is covered by the operculum. The latter is probably lifted by the continuous and violent movements of the embryo and frequently drops off entirely, leaving the opening unguarded. I occasionally observed embryonated eggs without an operculum before the larva had even begun to emerge from the shell.

Hatching was seldom observed in eggs that were kept dry on glass slides. Moistening the eggs with water or salt solution usually resulted in hatching, the percentage of hatching eggs varying considerably in different preparations. As a rule relatively few hatching eggs were observed in cover-glass preparations, but in several instances over 50 per cent of the eggs in such preparations hatched. The larva emerges from the shell either head first or tail first, and some forms appear to experience considerable difficulty in wriggling out of the shell. A hatching form in which part of the larva is outside of the shell and the remaining part is still within the shell is shown in Plate 1, fig. 11. As the egg opening is too small to enable the worm to wriggle out easily, it is seen to be constricted a little above the point of insertion in the shell opening, that portion just having slipped through.

I have frequently observed a similar condition in the hatching of certain Strongylidæ, and in these forms I observed a constriction at the point of insertion in the ruptured portion of the shell and a streaming movement of the granular larval substance from the portion of the worm that was still inclosed in the shell to that outside of the shell, thus rendering the former more compressible and making it possible for the larva to pull itself through a narrow opening.

That hatching of *Oxyuris equi* in vitro is purely accidental is evident from the fact that larvæ which emerge from the eggshells into water burst, owing to excessive absorption of the fluid, thus showing conclusively that the larvæ are not destined to a free-living existence. Larvæ that emerge from their eggshells into physiological salt solution do not become plasmoptized, but move about rather sluggishly. No signs of molting in vitro have been detected in these larvæ.

In experimental animals, hatching occurs in the small intestine, as will be shown presently, and the empty eggshells are nearly always without the operculum. The larvæ appear coarsely granular, and the granules obscure the internal organs.

FEEDING EXPERIMENTS

Many attempts were made to bring about artificial infection of guinea pigs with *Oxyuris equi* with a view of determining the behavior of the larvæ in these animals, with special reference to their possible migration through various organs comparable to the migrations of *Ascaris* larvæ. *Oxyuris equi* eggs cannot be sucked up in pipettes for purposes of feeding them to animals, because they stick to the surface of the glass. After several trials the following method was selected as being the most suitable for the purpose. Beakers containing eggs on the surface of liquid media were tilted, thus causing the eggs to adhere to the sides of the vessel. In an hour or two, the eggs were sufficiently dry and were scraped off with a knife and placed in small gelatine capsules which were forced down the œsophagus of the guinea pigs.

Guinea pigs were killed within eighteen, twenty-four, and forty-eight hours after feeding them eggs, as well as after longer intervals, and various portions of the alimentary canal were examined for the detection of larvæ but none were found. Numerous press preparations of the liver, lungs, and other organs, as well as of the blood, also yielded negative results. That the larvæ hatched in these guinea pigs was evident from the fact that empty eggshells which had lost their opercula were found in the fæces of these animals. In the earlier feeding experiments the eggshells were overlooked because the fæcal sediment alone was examined. The shells are absent in the sediment but float on the surface of the fæcal emulsions.

Guinea pigs killed within an hour or two after they had been fed eggs of *Oxyuris equi* contained nonhatched eggs in the stomach, and nonhatched eggs, free larvæ, and empty eggshells in the intestine. The embryonated eggs in the stomach exhibited no movements. In view of the fact that larvæ readily emerge from the shells in vitro, their failure to hatch in the stomach is probably due to a paralyzing effect of the stomach environment on their movements, thus preventing their emergence from the shell.

Seurat(8) quotes Heller (1913) who states that the pinworm of man, *Enterobius* (*Oxyuris*) *vermicularis*, hatches in the

small intestine where it molts twice. Cobb,(1) on the other hand, found that *Enterobius vermicularis* hatched in the human stomach when capsules containing these eggs were swallowed. Cobb states that the capsules were not dissolved and that a considerable amount of gastric fluid entered them. It is possible, of course, that the larvæ in Cobb's experiments emerged from the shells before the gastric fluid entered the capsules.

In view of the rapid disappearance of the larvæ from guinea pigs, no observations on molting were made. Repeated fæcal examinations of guinea pigs that were fed *Oxyuris* eggs failed to reveal any larvæ, and it may be taken for granted that these were digested in the intestines of these animals.

Whether the failure to find larvæ in the lungs and liver of guinea pigs that were fed eggs of *Oxyuris equi* may be accepted as conclusive proof that migrations to these organs do not occur in the course of the life cycle of these parasites is impossible to determine definitely from the data at hand. It is probable, however, that such migrations do not occur in the life history of *Oxyuris equi,* development being simple and direct following ingestion of embryonated eggs.

Following the discovery of the migrations of the larvæ of various Ascaridæ, attempts were made by various investigators to discover migrating larvæ in the life history of more or less common nematodes, but these attempts have been in the main unsuccessful. Thus Füllerborn(2) failed to observe migrations of larvæ of *Trichuris trichiura,* a nematode parasitic in the lower portion of the digestive tract of man, whose morphological affinities with *Trichinella spiralis,* a nematode whose larvæ invade the blood stream, warranted the expectation that a migration of larvæ would probably occur. Füllerborn observed, contrary to his expectations, the beginning of development of these larvæ in the cæcum of rabbits and guinea pigs. Graybill(3) and Riley(7) likewise report negative results with *Heterakis papillosa,* a nematode parasitic in the cæcum of chickens and other birds, whose development following ingestion of embryonated eggs took place in the normal habitat of this parasite. I have repeatedly fed the eggs of *Ascaridia perspicillum,* a nematode parasitic in the intestines of chickens, to guinea pigs and chicks and I have been unable to demonstrate migrations of the larvæ despite careful and tedious examinations of the liver, lungs, and other organs. On the contrary, I found that the larvæ develop in the lower portion of the small intestine of guinea pigs and chicks where they increase considerably in size. Ransom,(6)

on the other hand, found larvæ in the lungs of a guinea pig that had been fed infective larvæ of the stomach worm of sheep and cattle, *Haemonchus contortus.*

Füllerborn,(2) who carried out some preliminary experiments with the pinworm of man, *Enterobius* (*Oxyuris*) *vermicularis*, expresses the view that a migration of the larvæ of this parasite to the liver and lungs appears improbable, in view of the phylogenetic position of the Oxyuridæ.

The failure to find larval migrations in the Heterakidæ (*Heterakis* and *Ascaridia*), a group that is zoölogically more closely related to the Ascaridæ than are the Oxyuridæ, does not warrant the expectation, from the phylogenetic viewpoint, that the larvæ of oxyurids undergo migrations comparable to those of ascarids.

DEVELOPMENT OF OXYURIS EQUI IN THE HORSE

Railliet and Henry(5) described larval forms of *Oxyuris equi* from the horse measuring from 5 to 10.5 millimeters, in which the anus was situated relatively far from the posterior extremity; they also described larvæ of less-common occurrence, from 5 to 6 millimeters in length, in which the distance of the anus from the posterior extremity was shorter than in the former types. Railliet and Henry expressed the opinion that these forms represented males and females, respectively, and they predicted that following one more molt (the final larval molt), sex differentiation would become apparent. Recently Ihle and Van Oordt(4) found larvæ of *Oxyuris equi* in a similar stage of development, the smallest form measuring a little less than 3 millimeters. These writers also found molting forms and their observations on these larvæ established the correctness of the opinions expressed by Railliet and Henry regarding sexual differentiation of the larvæ subsequent to the final larval molt.

SUMMARY AND CONCLUSIONS

The data presented in the foregoing pages can be briefly summarized as follows:

1. Long-tailed horse oxyurids (*mastigoides* type) commonly oviposit in vitro, the eggs being segmented when they are discharged from the uterus. Uterine eggs that are liberated by cutting up female worms are nonsegmented and do not develop in vitro. Short-tailed oxyurids (*curvula* type) rarely oviposit in vitro. Eggs that are normally discharged from these forms develop normally in vitro.

2. Oviposition is preceded by marked peristaltic movements of the uterus, and following the expulsion of the eggs the females become quiescent and exhibit no further signs of vitality.

3. The eggs of *Oxyuris equi* develop rapidly and are embryonated in about four days.

4. Exposure of eggs to air appears to be requisite to development. The moisture content of the eggs is protected by a gluey water-insoluble substance, which accounts for the readiness with which the parasites develop in a dry place.

5. Continued exposure of embryonated eggs to environmental conditions (dry and moist) results in a gradual lowering of their vitality, and after a few weeks of such exposure they lose their vitality entirely.

6. Embryonated eggs of *Oxyuris equi* hatch in vitro, but the larvæ die in water as a result of plasmoptysis. The larvæ retain their vitality for a short time in physiological salt solution, and although they show sluggish movements they do not molt in vitro.

7. In guinea pigs hatching larvæ were not observed in the stomach. Emergence of larvæ from the eggshell through the birth pore in the shell that is guarded by the operculum occurred in the small intestine.

8. *Oxyuris equi* larvæ were rapidly eliminated from the digestive tract of guinea pigs, and no evidence of an invasion of the liver, lungs, and other organs could be found in these animals.

9. The life history of *Oxyuris equi* appears to be simple and direct. Following oral infection, the larvæ hatch in the intestine, settle down in the cæcum and colon, and by successive molts attain sexual differentiation.

10. On the basis of the foregoing observations it can be safely concluded that the eggs of *Oxyuris equi* must be eliminated from the host before development can take place, and that horses become infected as a result of swallowing water or food that has become contaminated with the eggs.

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ILLUSTRATIONS

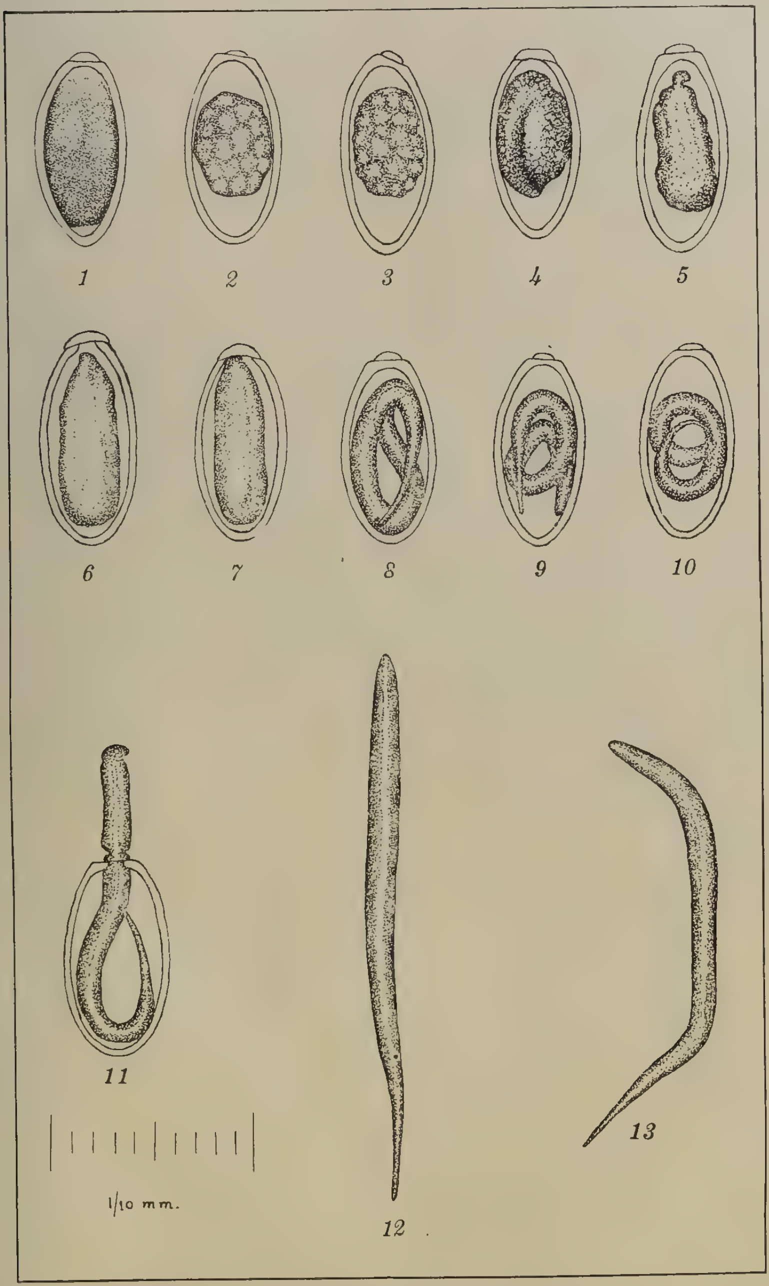

PLATE 1. EGGS AND LARVÆ OF OXYURIS EQUI.

METABOLISM EXPERIMENTS WITH FILIPINO STUDENTS IN THE UNITED STATES [1]

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Published studies on the nutrition of the Filipinos are very few. Aron and Hocson's work (3) is the only metabolic balance experiment on Filipinos reported in the literature. The need for further investigation along this line is therefore evident. The present paper is intended as a forerunner of other work of a similar nature which is being undertaken by the biological chemistry section of the College of Agriculture, University of the Philippines.

REVIEW OF THE LITERATURE

The following review of the literature shows that very little study has been done on the nutrition of Filipinos.

A food, to be adequate, must furnish the body not only with the necessary calories in the form of proteins, fats, and carbohydrates, but also with enough of the inorganic elements of which the body is composed. In addition to these, the so-called vitamines are indispensable.

In general it can be said that, given a free choice, the Filipinos, just as any other people, will take adequate diet. Instinct plays an important rôle in this. Unfortunately, one cannot always get the food he wants, and is thus forced to take whatever is available. Poverty and lack of supply are what generally limit the food choice of an individual.

Carbohydrates.—Rice is very rich in carbohydrates and, since it is the principal food of Filipinos, it is very easy to see that they are surely getting enough of this foodstuff for the needs of the body. Aron (1) found that the Filipino prisoners in Manila were getting an average of 510 grams of carbohydrates daily, and that a Filipino workman consumed 525 grams. Roxas and

[1] The data in the present paper are taken from the dissertation presented by me for the degree of Doctor of Philosophy, Yale University, 1922.

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Collado(17) calculated that the average intake of each student who ate in the college mess at the College of Agriculture, Los Baños, was 506 grams of carbohydrates daily. Collado (unpublished) has found that the carbohydrate intake of each student in that college who prepared his meals himself was 521 grams, while that of the barrio (rural) people was 444 grams. When we consider the small stature of Filipinos, we can see that they are getting a much greater quantity of carbohydrates than is demanded by the Voit standard.

Fats.—Osborne and Mendel(15) have shown that it is possible for animals to live without eating more than traces of true fat. According to Aron(1) Filipino prisoners got 27 grams of fat per man daily. Roxas and Collado found that at the students' mess mentioned the fat intake was 38 grams per person. Collado found that students who cooked their food themselves consumed 20 grams each daily, and the barrio people, 14 grams. It will be observed that the intake of fat was proportional to the pecuniary ability of the people. The students who ate at the mess were generally better off financially than those who cooked their food themselves, and the barrio families investigated were poorer than the students.

Inorganic salts.—From what foods do the Filipinos get their necessary quota of inorganic salts? Analysis of most of their food materials for inorganic constituents is lacking, so that an answer to this important question cannot even be attempted. Aron and Hocson found that a diet consisting principally of rice and vegetable foods did not cover the demand of the body for phosphorus. Polished rice is low in ash, and especially in phosphorus, and a diet of rice, plus bread, bacon, fish, and other foods poor in this element was not enough to produce a positive phosphorus balance. The balance became positive when unpolished rice, rice bran, or phytin was added to the ration. The studies of the diet of the people in Los Baños by Roxas and Collado indicate that the Filipino dietary may be deficient in calcium.

In connection with this problem, two habits of some of the people, which may possibly indicate that their common food is poor in inorganic salts are worth mentioning: (*a*) The bones of the fish are usually eaten as well as the meat. It has been stated already that rice is low in ash. Dry fish is a very common food. (*b*) While as a rule the unmarried Filipino women do not chew buyo and betel leaves and smoke neither cigars nor cigarettes, when they get married and become pregnant or when nursing, many of them, especially the poor ones, get the "buyo-chewing"

habit [3] and eat cigar or cigarette ash. It is not uncommon to find pregnant women who dislike the smell of tobacco, but who nevertheless eat the ash.

Proteins.—Is the protein requirement of Filipinos the same as that of other people? Careful consideration of all the literature up to date shows that this question cannot be answered at present. It is my intention to study this phase in the near future. Aron and Hocson found that it was not possible to establish nitrogen equilibrium with the simple Filipino diet of rice, bread, fish, sugar, bacon, and coffee, even in cases where the nitrogen intake was comparatively high (8.5 to 9.95 grams per day) if the total caloric intake was less than 1,800 calories per 50 kilograms of body weight. They state further: (3)

> * * * On the other hand, if the number 1,800 was equalled or exceeded, then 9 grams of nitrogen per 50 kilograms of body weight were sufficient. If a less quantity of nitrogen than the above figure was taken with the food, then the loss of nitrogen exceeded the amount taken, even if the number of calories reached 2,200. However, with an intake of 5 to 6 grams of nitrogen, the deficit amounted to less than 2 grams * * *.

From this they deduced that in some instances 8 grams of nitrogen per 50 kilograms of body weight, or 0.16 gram per kilogram of body weight, would be sufficient. Their value was higher than the lowest limit found by other authors who have succeeded in establishing nitrogen equilibrium on 0.1 gram per kilogram of body weight.

Collado found that the average intake of each member of two poor families in Los Baños was 9.4 grams nitrogen with a total of 2,090 calories. The prisoners in Manila were found by Concepcion (9) to have an average daily intake of 8.5 grams of nitrogen with a total of 1,799 calories. Although the latter author was of the opinion that the amounts found by Collado and by himself were sufficient to keep the body in nitrogen equilibrium, Aron and Hocson's finding that at least 1,800 calories per 50 kilograms of body weight are needed to preserve nitrogen equilibrium led him to conclude that the requirement of calories estimated by Collado and by himself was not adequate for the body. The reason for this conclusion is not obvious. According to Aron and Hocson's results at least 36 calories per kilogram of body weight are needed to keep the body in nitrogen balance. Collado's data show that his subject had an intake of 40 calories

[3] Thick paste of calcium hydroxide is spread on fresh betel leaves. This together with the buyo is a favorite chew of many women.

per kilogram of body weight (2,090 per 52 kilograms of body weight). Concepcion's data show an intake of 35 calories per kilogram of body weight (1,799 per 52 kilograms of body weight). Aron and Hocson concluded that when the caloric requirement of 1,800 per 50 kilograms of body weight was satisfied, 0.16 gram nitrogen per kilogram of body weight was sufficient to establish nitrogen balance. The nitrogen intake of Collado's subjects was 0.18 gram per kilogram of body weight, and that of Concepcion's 0.15 gram. Hence, it is reasonable to assume that the subjects of these two investigators were getting enough nitrogen to prevent loss of this element from the body.

EXPERIMENTAL

The following nitrogen-metabolism experiments were conducted to find out whether it is possible for Filipinos, who have resided one year or more in the United States and have become accustomed to American diet, to remain in nitrogen equilibrium when given a Filipino food of rice, fish, meat, and vegetables. The subjects, all males and healthy, were four Philippine Government students taking post-graduate courses at Yale.

To simplify the analyses and the preparation of the foods, salmon and ham were used as the fish and meat foods, respectively, while lettuce, sweet potato, and banana formed the vegetables. The nitrogen was determined in the food as prepared for eating, and control determinations were made now and then to guarantee that the nitrogen content of each particular food did not vary too widely.

Except for the coffee and the little powdered milk and sugar which go with it for the sake of savor, no restriction was made as to the amount of food each subject should take. All were allowed to eat as much as they wanted. To lessen the monotony of the ration, meat and fish were given on alternate days, as was also done with potatoes and lettuce.

The period at which the actual analyses were made was preceded by a preliminary period of at least three days, during which the actual experimental diet was ingested. Charcoal in gelatin capsules was used for marking the fæces; the latter was mixed with a little alcohol and hydrochloric acid before drying on the water bath. Thymol was used as a preservative for the urine. The food was purchased and cooked by me.

Methods used.—The acidity was determined by titration with 0.1 *N* sodium hydroxide, according to Folin's method; total nitrogen, by Kjeldahl's; creatinine, by Folin's colorimetric; uric

acid, by Folin-Shaffer's; sodium chloride according to Volhard-Arnold; and calcium oxide, by McCrudden's method. All of these procedures are described in the excellent manual of Underhill.(18) The caloric value of the different foods was estimated from Atwater's(4) tables for American food materials. The surface area was calculated by the use of Meeh's formula, and the Du Bois value of 39.7 calories(13) per square meter of body surface was taken as the standard in calculating the basal metabolism.

DISCUSSION OF RESULTS

As will be seen in Tables 1 to 8, a positive nitrogen balance was obtained in all of the series. In no case was the caloric intake of each person less than 14 per cent above the basal requirement, a value calculated by Lusk as the excess, above the starvation minimum, needed for maintenance. Little change in weight was observed in any of the subjects.

Table 9 shows the average daily nitrogen and the caloric intake of the four Filipinos concerned.

Table 10 shows that the students consumed more calories per kilogram of body weight than either the people of Los Baños or the prisoners in Manila; more than is required by the Voit, the Rubner, or the Chittenden(6, 7) standard; but less than the recorded intake of Japanese students (Oshima, 16) or the intake required by Atwater's standard (Lusk, 13).

A study of the nitrogen intake (Table 10) shows that my subjects ingested more nitrogen than the reported intake of Filipinos living in the Philippines; more than the intake of Japanese students; and almost as much, per kilogram of body weight, as required by the accepted American and European standards. Almost one-half of the nitrogen intake of the students investigated by Collado, and more than two-thirds of the intake of Aron and Hocson's subjects, came from the rice eaten. Less than one-third of the nitrogen intake of my subjects came from rice. The reasons for the comparatively high intakes of meat (nitrogenous food) are obvious. Animal foods are usually more expensive than either the vegetable or the cereal foods. Collado's subjects paid for the food they ate. Aron and Hocson intentionally made rice the basis of their diet, from which it can be deduced that they did not amply provide meat for their men. Aron(2) also found that the people of Taytay obtained more than half of their nitrogen need from rice. They, likewise, paid for their food. Besides, it is the habit of the majority of the people

in the Philippines to eat as much rice and as little meat as possible. Some take meat only to improve the taste of the rice. Mothers often say to the children, "Be sparing with your meat, but always eat much rice."

As mentioned above, my subjects had been in America for more than one year and were therefore accustomed to American diet. Naturally they longed for Filipino food. During the experiments the food was given to them gratis. Since there was no restriction as to the amount they should eat, it was no wonder that they ate to their hearts' content, and consumed much more meat than do their countrymen at home. That they enjoyed the rations was shown in their desire that the experiments be continued longer.

Observations made among some of the Filipino students in New York City who cooked their food themselves showed that, when they had plenty of money, they ate more meat and less rice than when in pecuniary difficulty.

Incidentally it will be noted that F.O.S. (Tables 1, 2, and 3) had a higher nitrogen intake in the second period than in the first and third. In the first period he was eating alone; in the second also he was alone, but took 5 grams of brewers' yeast daily; and in the third, he had a companion at the table. Did yeast serve as an appetite improver here? (Cowgill, 10; Karr, 12.)

The nitrogen and the caloric intakes of my subjects were all higher than Aron and Hocson found necessary for establishing nitrogen equilibrium; herein lies the reason for their giving positive nitrogen balance in all cases.

URINE ANALYSES

The analyses of the urine (Table 11), compared with those of other urines as given in Table 12, show nothing of particular interest.

The average specific gravity is lower and the average daily volume larger than those of the urine of Filipinos living in the Philippines, but not than those of white men living in either the Temperate or the Tropic Zones. The difference in both the volumes and the specific gravities may be partly explained by the difference in temperature; my experiments were made in late fall while those in the Philippines, it should be borne in mind, were performed at tropical temperature.

The urinary nitrogen figures are also higher than those for other tropical people observed in their own localities (see Table

12). This is due to the greater comparative nitrogen intake of the subjects investigated, in conformity with the well-known fact that, within certain limits, the nitrogen metabolism can be maintained at different levels.

The acidity is lower than that of the average urines of Europeans or Americans, but higher than that of the urines of the people of Singapore (Campbell, 5).

Table 13 shows the day and night variations in some of the constituents of the urine of F.O.S.

SUMMARY

Filipinos who had become accustomed to American food showed positive nitrogen balances when given their native diet, and this diet as selected furnished enough calories for the nutritive equilibrium.

The results obtained were compared with previous work done in the Philippines.

Analyses of urines for some of the constituents are recorded.

ACKNOWLEDGMENT

I desire to express my hearty thanks to Prof. Lafayette B. Mendel for suggesting this subject and for his advice during the progress of the work.

TABLE 1.—*Food intake of F.O.S., October 26 to 29, 1920.*

Food.	October 26.	October 27.	October 28.	October 29.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	673	615	793	693	2,774	0.42	11.65
Salmon	159		163		322	4.15	13.36
Ham		120		97	217	4.69	10.17
Lettuce	59		68		127	0.21	0.26
Sweet potato		176		216	392	0.15	0.59
Banana	130	123	65	107	425	0.22	0.94
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatin capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	37.32
Output in urine	30.57
Output in fæces	5.02
Total output in excreta	35.59
Balance, four-day period (plus)	1.73
Balance, average per day (plus)	0.43

Caloric intake.

	Cals.
Total estimated caloric intake	6,270
Average estimated daily intake	1,570
Estimated basal metabolism	1,370
Caloric intake, 15 per cent above basal metabolism.	

Body weight, without clothing.

	Kilograms.
October 26	40.1
October 30	39.4

TABLE 2.—*Food intake of F.O.S., November 8 to 11, 1920.*

Food.	November 8.	November 9.	November 10.	November 11.	Total food.	Nitrogen.	
	g.	g.	g.	g.	g.	P. ct.	g.
Rice	831	761	956	849	3,397	0.42	14.27
Salmon		121		148	269	4.15	11.16
Ham	160		148		308	4.69	14.44
Lettuce	59		69		128	0.21	0.26
Sweet potato		217		258	475	0.15	0.71
Banana	72	101	118	100	391	0.22	0.86
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Yeast	5	5	5	5	20	7.58	1.51
Two gelatin capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	43.56
Output in urine	33.52
Output in fæces	6.83
Total output in excreta	40.35
Balance, four-day period (plus)	3.21
Balance, average per day (plus)	0.80

Caloric intake.

	Cals.
Total estimated caloric intake	7,180
Average estimated daily intake	1,790
Estimated basal metabolism	1,370
Caloric intake, 31 per cent above basal metabolism.	

Body weight, without clothing.

	Kilograms.
November 8	40.0
November 12	39.4

TABLE 3.—*Food intake of F.O.S., November 27 to 30, 1920.*

Food.	November 27.	November 28.	November 29.	November 30.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	734	763	814	866	3,177	0.42	13.34
Salmon	--------	135	--------	156	291	4.15	12.07
Ham	102	--------	178	--------	280	4.69	13.13
Lettuce	46	--------	48	--------	94	0.21	0.19
Sweet potato	--------	235	--------	222	457	0.15	0.68
Banana	148	102	166	90	506	0.22	1.11
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatin capsules	--------	--------	--------	--------	--------	--------	0.04

Nitrogen balance.

	Grams.
Total intake in food	40.87
Output in urine	32.40
Output in fæces	6.98
Total output in excreta	39.38
Balance, four-day period (plus)	1.49
Balance, average per day (plus)	0.37

Caloric intake.

	Cals.
Total estimated caloric intake	7,100
Average estimated daily intake	1,770
Estimated basal metabolism	1,370

Caloric intake, 29 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
November 27	40.0
December 1	39.2

TABLE 4.—*Food intake of J.L.C., November 27 to 30, 1920.*

Food.	November 27.	November 28.	November 29.	November 30.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	930	832	899	1,034	3,695	0.42	15.51
Salmon	--------	208	--------	131	339	4.15	14.06
Ham	149	--------	130	--------	279	4.69	13.08
Lettuce	30	--------	49	--------	79	0.21	0.16
Sweet potato	--------	219	--------	162	381	0.15	0.57
Banana	257	181	289	171	898	0.22	1.97
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules	--------	--------	--------	--------	--------	--------	0.04

Nitrogen balance.

	Grams.
Total intake in food	45.70
Output in urine	34.93
Output in fæces	8.64
Total output in excreta	43.57
Balance, four-day period (plus)	2.13
Balance, average per day (plus)	0.53

Caloric intake.

	Cals.
Total estimated caloric intake	8,030
Average estimated daily intake	2,000
Estimated basal metabolism	1,430

Caloric intake, 40 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
November 27	43.1
December 1	43.2

TABLE 5.—*Food intake of J.L.C., December 4 to 7, 1920.*

Food.	December 4.	December 5.	December 6.	December 7.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	1,106	821	1,096	1,201	4,224	0.42	17.74
Salmon		151		233	384	4.15	15.93
Ham	133		222		355	4.69	16.64
Lettuce	76		35		111	0.21	0.23
Sweet potato		198		106	304	0.15	0.45
Banana	227	154	249	290	920	0.22	2.02
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	53:36
Output in urine	37.78
Output in fæces	8.27
Total output in excreta	46.05
Balance, four-day period (plus)	7.31
Balance, average per day (plus)	1.82

Caloric intake.

	Cals.
Total estimated caloric intake	8,900
Average estimated daily intake	2,220
Estimated basal metabolism	1,430

Caloric intake, 55 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 4	43.0
December 8	43.6

TABLE 6.—*Food intake of E.G.A., December 4 to 7, 1920.*

Food.	December 4.	December 5.	December 6.	December 7.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	1,021	1,008	1,010	895	3,934	0.42	16.52
Salmon		152		186	338	4.15	14.02
Ham	217		149		366	4.69	17.16
Lettuce	43		31		74	0.21	0.15
Sweet potato		134		141	275	0.15	0.41
Banana	238	247	242	293	1,020	0.22	2.24
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	50.85
Output in urine	43.56
Output in fæces	6.01
Total output in excreta	49.57
Balance, four-day period (plus)	1.28
Balance, average per day (plus)	0.32

Caloric intake.

	Cals.
Total estimated caloric intake	8,590
Average estimated daily intake	2,140
Estimated basal metabolism	1,690

Caloric intake, 26 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 4	55.2
December 8	55.7

TABLE 7.—*Food intake of E.G.A., December 11 to 14, 1920.*

Food.	December 11.	December 12.	December 13.	December 14.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	805	1,062	889	925	3,681	0.42	15.46
Salmon		220		267	487	4.15	20.21
Ham	199		191		390	4.69	18.29
Lettuce	66		72		138	0.21	0.29
Sweet potato		149		100	249	0.15	0.37
Banana	200	136	235	260	831	0.22	1.82
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	56.79
Output in urine	45.50
Output in fæces	10.10
Total output in excreta	55.60
Balance, four-day period (plus)	1.19
Balance, average per day (plus)	0.30

Caloric intake.

	Cals.
Total estimated caloric intake	8,480
Average estimated daily intake	2,120
Estimated basal metabolism	1,690

Caloric intake, 25 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 11	55.0
December 15	55.3

TABLE 8.—*Food intake of J.M.E., December 11 to 14, 1920.*

Food.	December 11.	December 12.	December 13.	December 14.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	1,159	994	1,180	1,009	4,342	0.42	18.23
Salmon		209		222	431	4.15	17.88
Ham	180		156		336	4.69	15.75
Lettuce	46		60		106	0.21	0.22
Sweet potato		256		374	630	0.15	0.94
Banana	206	150	224	242	822	0,22	1.80
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	55.17
Output in urine	44.08
Output in fæces	6.81
Total output in excreta	50.89
Balance, four-day period (plus)	4.28
Balance, average per day (plus)	1.07

Caloric intake.

	Cals.
Total estimated caloric intake	9,650
Average estimated daily intake	2,410
Estimated basal metabolism	1,540

Caloric intake, 56 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 11	48.0
December 15	48.3

TABLE 9.—*Average daily nitrogen and caloric intake of the Filipinos investigated.*

Name.	Body weight.	Total nitrogen.	Nitrogen per kilogram of body weight.	Total calories.	Calories per kilogram of body weight.
	Kilos.	*g.*	*g.*		
F.O.S	40	10.16	0.25	1,710	42
J.L.C	43	12.38	0.28	2,110	49
E.G.A	55	13.46	0.24	2,130	39
J.M.E	48	13.79	0.29	2,410	50
Average	47	12.45	0.26	2,090	45

TABLE 10.—*Nitrogen and caloric intake of Filipinos as compared with well-known dietary standards.*

	Body weight.	Total nitrogen.	Nitrogen per kilogram of body weight.	Total calories.	Calories per kilogram of body weight.
	Kilos.	*g.*	*g.*		
Rubner standard	70	20.3	0.29	2,860	41
Voit standard	70	18.8	0.27	3,050	43
Atwater standard	70	20.0	0.28	3,400	49
Chittenden standard	70	9.4	0.13	2,600	37
Japanese students	44	8.6	0.20	2,260	51
People in Los Baños	52	9.4	0.18	2,090	40
Prisoners in Manila (Concepcion)	52	8.5	0.16	1,799	35
Filipinos (Aron and Hocson)	50	8.0	0.16	1,800	36
Filipino students at Yale	47	12.4	0.26	2,090	45

TABLE 11.—*Analyses of urines of Filipino students at Yale University (1920).*

Subject.	Date.	Specific gravity 1.0.	Volume.	Acidity 0.1 *N* sodium hydroxide.	Total nitrogen.	Creatinine.	Uric acid.	Sodium chloride.	Calcium oxide.
	1920		*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*	*g.*
F.O.S	October 26	0.013	1,180	269	7.48	1.26	0.28	8.9	0.37
Do	October 27	0.012	980	235	7.31	1.11	0.43	4.8	0.19
Do	October 28	0.012	1,120	230	7.64	1.22	0.39	5.3	0.22
Do	October 29	0.012	1,240	203	8.14	1.03	0.29	6.0	0.27
Do	November 8	0.014	960	221	8.62	1.11	0.38	4.6	0.19
Do	November 9	0.012	1,100	238	7.74	1.24	0.39	5.4	0.22
Do	November 10	0.017	895	233	8.46	1.05	0.48	6.0	0.21
Do	November 11	0.014	1,115	313	8.70	1.29	0.39	5.7	0.23
J.L.C	November 27	0.016	985	204	8.04	1.12	0.48	6.9	0.23
Do	November 28	0.017	850	207	8.24	1.30	0.49	6.0	0.22
Do	November 29	0.025	690	132	8.60	1.26	0.60	7.0	0.18
Do	November 30	0.017	1,120	282	10.05	1.44	0.58	9.3	0.23
E.G.A	December 4	0.025	760	168	10.53	1.57	0.53	7.8	0.14
Do	December 5	0.017	1,180	300	11.65	1.68	0.70	7.2	0.13
Do	December 6	0.016	1,600	154	11.63	1.64	0.74	7.3	0.19
Do	December 7	0.014	1,250	266	9.75	1.52	0.51	7.7	0.15
J.M.E	December 11	0.023	910	234	11.01	1.47	0.56	9.0	0.22
Do	December 12	0.030	665	288	11.21	1.63	0.64	7.6	0.25
Do	December 13	0.016	1,400	243	10.29	1.41	0.55	10.9	0.22
Do	December 14	0.017	1,285	300	11.57	1.45	0.76	8.1	0.27
Average		0.016	1,064	236	9.33	1.34	0.51	7.1	0.22

TABLE 12.—*Comparison of the analyses of the urines of the Filipino students at Yale with other normal urines.*

	Body weight.	Specific gravity 1.0.	Volume.	Acidity 0.1 *N* sodium hydroxide.	Total nitrogen.	Nitrogen per kilogram of body weight.	Creatinine.	Uric acid.	Sodium chloride.	Calcium oxide.
	Kilos.		*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*
Europeans (McCay, 1908)	70.0	0.020	1,440	----------	18.00	0.26	1.55	0.75	15.0	----------
Americans (Folin, 1905)	63.0	0.022	1,430	617	16.00	0.25	1.55	0.37	10.1	----------
Bengalis (McCay, 1908)	52.0	0.013	1,200	----------	6.00	0.11	----------	0.45	10.0	----------
Races in Singapore (Campbell, 1919)	52.0	0.016	1,046	281	8.39	0.16	1.10	0.33	6.0	----------
Europeans in the Tropics (Young, 1915)	60.0	0.021	1,070	----------	11.49	0.19	----------	----------	----------	----------
Filipinos in the Philippines (Concepcion, 1918)	51.0	0.019	936	----------	7.01	0.14	1.48	0.37	5.8	----------
Medical students in the Philippines (Concepcion, 1918)	51.0	0.021	924	----------	7.75	0.15	1.69	0.44	5.7	----------
Filipino students at Yale	47.0	0.016	1,064	236	9.33	0.20	1.34	0.51	7.1	0.22

TABLE 13.—*Day and night variations in the urine of F.O.S.*

Date.	Specific gravity 1.0.		Volume.		Acidity 0.1 *N* sodium hydroxide.		Total nitrogen.		Creatinine.	
	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.
			cc.	*cc.*	*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*
1920										
October 26	0.013	0.014	740	440	126	143	3.93	3.55	----------	----------
October 27	0.010	0.014	510	470	87	148	3.15	4.16	----------	----------
October 28	0.010	0.015	680	440	102	128	3.68	3.96	----------	----------
October 29	0.014	0.010	575	665	95	108	4.52	3.62	----------	----------
November 8	0.010	0.018	540	420	84	137	4.05	4.57	0.56	0.55
November 9	0.011	0.013	560	540	95	143	3.58	4.16	0.63	0.61
November 10	0.017	0.017	415	480	100	133	3.56	4.90	0.52	0.53
November 11	0.012	0.016	635	480	117	196	3.93	4.77	0.62	0.67

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NOTES ON PHILIPPINE SHARKS, I

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ONE PLATE

Throughout the ages sharks have been of well-nigh universal interest. Without the gorgeous colors or flowerlike brilliancy of some fishes or the superb symmetry and grace of others, they yet irresistibly attract attention. Though as a rule of a dull uniform gray or bluish cast and without beauty of form, by their size, speed, greediness, and ferocity they have aroused curiosity from earliest times. Though a few sharks are notable for singularity of shape, it is their more degenerate and less-active kindred, the skates and rays, that have developed the strangest forms and the most uncanny powers.

Although some sharks attain a length of only a few inches, even when fully matured, as a whole they are of large size, and certain sharks and rays are the largest of all fishes. Many species of sharks are very ferocious when hungry and do not hesitate to attack any other animal in the water, regardless of its size. Sharks are no worse in this regard than many other fishes, as any very large carnivorous fish may be dangerous to man. Barracuda and the giant sea basses of the East Indies and Polynesia are more dreaded in some localities than are sharks. No shark is more ferocious or dangerous to man than are the small and apparently insignificant caribe fish of the South American rainy tropics.

The sharks and their allies represent an entirely distinct and divergent line from that of the bony fishes. They have no air bladder, no true scales, and no membrane bones, the operculum being always absent in the living species, while the skeleton not only presents a number of peculiarities but also is much less specialized both in form and in material, always remaining more or less cartilaginous. The shoulder girdle is not fastened to the skull but to one of the vertebræ some distance behind it, so that there is a neck similar to that in higher animals. The males of all living species have attached to the ventral fins a pair of claspers or copulatory organs. These serve as a penis

by whose agency the semen is transmitted into the oviducts, impregnation being therefore internal in all sharks except those of the genus *Somniosus*, which includes two species of arctic and subarctic seas.

The eggs are few and large and may be developed externally when, with the exception of those of *Somniosus*, they are covered with a thick leathery or horny skin, or case, or they may be developed within the body of the mother. The cases of some shark eggs are spirally twisted, others are quadrangular with each of the four corners produced into a long filament. The egg cases of rays are wheelbarrow-shaped, with four "handles." These handles and stringy filaments serve to attach the eggs to fixed objects. In some species of rays the egg cases contain several eggs, each of which may develop.

In many sharks, and in some rays, a part of the oviduct becomes enlarged into a uterus, and in some of the sharks a placenta is formed similar in appearance to that of mammals but different in development.

The skin of sharks and rays may be naked, or it may be provided with bony or horny plates, but usually it is covered with placoid scales. These scales are minute, closely set spines situated on a broader base, each spine consisting of dentine covered with enamel; the base is composed of bone and the whole scale therefore has the same essential structure as a tooth. Placoid scales are usually so firmly attached to the skin that it is very difficult to remove them, while they are so hard they will take a stonelike polish. Formerly large quantities of shark skins were used for polishing wood and ivory; their fineness, hardness, and durability made them far superior to any other abrasive available for work of the highest quality. Even in spite of the great improvements in making emery and sand paper, cabinet makers still use some shagreen.

The principal use made of shark skins for many years has been in the manufacture of sword grips and sheaths, card cases, jewel boxes, and other small articles. Within the past five years improved methods of removing the scales and of tanning shark skins have been perfected and a rapidly increasing shark leather business is being developed. Shark skins are nonporous and therefore make a leather practically water and air proof. The last-named quality is a serious defect in the manufacture of shoes, but does not impair the value of the leather for many other purposes.

Sharks and skates are of world-wide distribution and occur from the upper Silurian deposits onward. Although most species are more or less solitary in habit, a few sometimes occur in vast schools and are distinctly gregarious at all times.

Though sharks and skates are but little eaten by Europeans and their descendants, practically all are edible and a few species are really very good food, ignorance and prejudice alone preventing them from being extensively used as food. To an extent little realized they are being increasingly utilized in the United States. Many of those caught in traps along the Atlantic coast are cut up so as to be unrecognizable and are marketed under the name of "deep water swordfish." Certain sharks make an acceptable canned product, though owing to the prejudice against shark meat they have been marketed under another name.

In the Philippines several species of sharks and rays are commonly seen in the markets and are esteemed as food. In some parts of the Islands, especially in the Sulu Archipelago, large numbers of sharks are caught for the fins alone, little use being made of the rest of the fish. The dried fins are exported to China, where they are in great demand as the basis for a delicious soup. The liver of sharks and rays is very rich in oil and in some parts of the world fisheries have been maintained for generations for the purpose of obtaining the oil, the rest of the animal being thrown away. Most of the oil is used in soap making, tanning, and other industries, but the best grade is refined and used as "cod-liver oil."

No systematic shark fisheries are conducted in the Philippines, but in the Sulu Archipelago many sharks are caught with hook and line or speared. Many others are captured in the fish traps which line the coasts, though their presence there or their capture in nets is more or less accidental.

In the modern method of developing shark fisheries the sharks are caught in specially designed gill nets, as ordinary nets are ruined by them. The hides are made into leather, the fins are prepared for the Chinese trade, and the oil is extracted from the livers; the meat and bones are cooked and ground into stock food and fertilizer. There are many localities in the Philippines where a large and profitable business in sharks could be developed. The preparation and export of shark fins is a business capable of great expansion. The choicest varieties fetch a very high price but Filipino fishermen make no systematic effort to get the better kinds, while the Chinese merchants who dry and

salt fish have such slipshod methods that their product is often inferior.

Most kinds of sharks are harmless to man, and they are not a serious menace to bathers in the Philippines; nevertheless, they are a factor to be considered in many places. Occasionally some one is either killed outright by a shark, so badly bitten as to die shortly afterward, or is seriously wounded. Bathing beaches having a reef or bar in front of them are usually safe, but bathers should never venture alone into deep water in the Philippines.

There are no authentic records of rays attacking man, though the gigantic rays known as mantas or "sea devils" are greatly feared by pearl divers. The sting rays, which have one or more large barbed spines on the long and flexible tail, inflict dangerous wounds when stepped upon. The jagged spine causes frightful injury and, due to the slime and dirt forced into the wound, infection usually follows.

Sawfish never attack man intentionally, but due to their size, strength, and terrific weapon they are greatly and justly dreaded when entangled in nets or caught in traps.

The sharks and rays of the Philippines are very imperfectly known, not more than half of the species being listed or represented in existing collections. Although they form a group of considerable economic importance in the Philippines this lack of knowledge is not surprising, since it is very difficult to collect and preserve the large adult forms.

In the present paper is described a new species, the type of a new genus, obtained at Dumaguete, Oriental Negros, in March, 1922. With it were also caught two other sharks, small dogfish, reported only once before from the Philippines. These three sharks were captured in a fish corral a few meters off shore, in water not over 6 meters deep.

Genus **HEMITRIAKIS** novum

This genus is distinguished from *Triakis*, to which it is most closely related, by the differences in the teeth, in the shape of the snout, in the lobe of the nasal valve, in the shape of the body, and in the subcaudal lobe.

Head much depressed anteriorly, flattened beneath except beneath the moderately long and pointed snout, where it is slightly convex; eyes with prominent nictitating membrane over lower portion; spiracles very small, behind eyes; nostrils very

far apart, without nasoral groove; mouth arched, with prominent labial folds; teeth of medium size, two transverse rows functioning in upper jaw and three in lower; in upper jaw are a few (two or three rows) very small erect median teeth with a central sharp-pointed cusp and usually two smaller ones at each side of its base; the remaining teeth are much larger, strongly oblique, with a longer sharp-pointed cusp directed outward toward the angle of the mouth, and with two or three much smaller denticles on the outer side; in lower jaw the teeth of the six median rows are larger than the upper median teeth, are erect or nearly so, and have a central cusp with from no denticles to three small ones on each side of base; the remaining rows are of teeth smaller than the opposing upper teeth, strongly oblique, with a larger cusp directed toward angle of mouth and one to four minute cusps or denticles on outer side; the fifth pair of gill slits is the smallest and is over the pectoral; the first dorsal is over the space between pectorals and ventrals, but much nearer the former; origin of second dorsal in advance of anal; caudal rather short, without a pit at its base, with a notch in the subcaudal lobe, and a moderately developed anterior lobe.

Body not compressed; lateral line noticeable, rather high up, beginning on head.

Hemitriakis leucoperiptera[1] sp. nov. Plate 1.

Head 4.775 in length, its greatest breadth a trifle more than half (50.4 per cent) of its own length; snout $3\frac{1}{13}$ in head; eyes $6\frac{1}{4}$ in head and a trifle less than twice in interorbital space; spiracles $5\frac{1}{3}$ in eyes; depth 7.95 in total length and 6.31 in length without caudal fin.

Head long, its profile descending very sharply from predorsal region, its anterior portion very low and depressed, with flattened crown and interorbital space; eyes large, much elongated, with a broad shagreen-covered nictitating fold; the small, slitlike spiracles just behind eyes; snout rather long and pointed, with a slightly rounded tip; nostrils as far apart as possible and nearer mouth than tip of snout; each anterior valve has an outer triangular pointed flap near inner angle of nostril and under and at right angles to it a smaller dividing fold or flap; each posterior valve has a slight fold, or ridge, near inner angle; mouth crescentic, its transverse length equal to interorbital space, with well-developed labial folds, the outer parallel with contour of head

[1] *Leucoperiptera* from λευκος, white; πεπι, around; and πτεπόυ, wing, or fin, in allusion to the white margin of the fins.

and half again as long as inner which parallels lower lip; teeth in $\frac{18}{34}$ rows, their description given under that of the genus.

Third gill slit largest and contained 8 in length of head; fifth smallest, being approximately three-fourths as large as third; in the type specimen margin of second gill slit on right side is curiously modified, running above and beyond third gill slit, as shown in the figure; this is evidently a congenital malformation.

Inner margin of pectorals four-fifths as long as outer margin, which is 0.8 the length of head; origin of first dorsal above posterior margin of pectorals; rear margin of both dorsals and anal crescentic, inner angle of each produced in a long pointed tip; origin of anal opposite middle of second dorsal; caudal rather short, a trifle less than the length of head; subcaudal narrow with a pointed and moderately long lobe near its origin and a notch near its extremity, the lobe 2.44 in length of caudal, with a deeply concave posterior margin; supracaudal rather thick, low, very little elevated.

Body very deep just before first dorsal, with a low dermal ridge between the dorsals and on the long caudal peduncle; trunk and tail rounded, not at all compressed; tail longer than head and trunk together, or 52.3 per cent of the entire length; scales small, very rough except on head where they are smooth, those on caudal smaller, five keeled, the central one terminating in a strong sharp point; numerous conspicuous mucus pores on top of snout and extending back as far as crown.

Color nearly uniform dark gray above lateral line, darkest on crown and snout and in front of first dorsal; paler below, becoming whitish or with a yellowish cast beneath; all the fins have a narrow white posterior margin.

Here described from the type specimen, a pregnant female, 955 millimeters long over all, obtained by me at Dumaguete in March, 1922, and containing twelve young nearly ready for delivery.

There are six females, varying in length from 202 to 218 millimeters, and six males, five ranging from 200 to 208 millimeters and one 220 millimeters long. All vary in certain particulars from the mother. The head is contained from 4.3 to 5 times in the total length; the extreme elevation of the predorsal region is wanting, the depth being contained from 9.3 to 10 times in the total length; the crown and interorbital region are also slightly convex. There is a black blotch on both dorsals and on the tip of the supracaudal, and two black blotches on the caudal peduncle

behind the second dorsal. As in all young the eyes are larger than in the adult, being contained 4 times or less in the head, while the spiracles are more open and about 4 in the eye. The subcaudal lobe is very slightly developed, its elongation evidently being a post-embryonic development.

Squalus fernandinus Molina. DOG FISH.

Squalus fernandinus MOLINA, Saggio sulla storia nat. Chili (1782); GARMAN, The Plagiostomia, Mem. Mus. Comp. Zool. Harvard College 36 (1913) 195.

Squalus philippinus SMITH and RADCLIFFE, Proc. U. S. Nat. Mus. 41 (1912) 677, pl. 51, fig. 1.

The genus *Squalus* is typically one of cool, temperate waters and is primarily distinguished by the conspicuous stout sharp spine in front of both the first and the second dorsal fins, and by the teeth which are alike in both jaws, with obique cusps and cutting edges nearly parallel with the edge of the jaw.

Smith and Radcliffe described a small male *Squalus*, 325 millimeters long, from the west coast of Luzon, under the name of *Squalus philippinus*. It was dredged off Sombrero Island, at a depth of 236 fathoms.

It is therefore a matter of considerable interest to find two more specimens, this time in shallow water, the species being apparently not considered rare by the Dumaguete fishermen.

My specimens are both females; they measure, respectively, 645 and 655 millimeters long over all. I follow Garman in placing *philippinus* under the synonymy of *S. fernandinus*.

Measurements.

	mm.	mm.
Length without caudal	515	530
Length over all	645	655
Head	140	153
Width of head	84	85
Snout from mouth	61	61
Snout from eye	47	47
Eye	30	31
Interorbital space	52	54
Mouth	45	45
Snout to origin of first dorsal	197	185
Origin of first dorsal to origin of second dorsal	210	235
Base of first dorsal	45	55
Base of second dorsal	30	45
Second dorsal to origin of caudal	70	70
Widest gill opening	15	15

ILLUSTRATION

[Drawings by M. Ligaya.]

PLATE 1. HEMITRIAKIS LEUCOPERIPTERA G. ET SP. NOV.

FIG. 1. Adult female, one-third natural size.
2. Gill slits on right side, showing congenital malformation.
3. Underside of snout.
4. A young male, taken from the female shown in fig. 1.

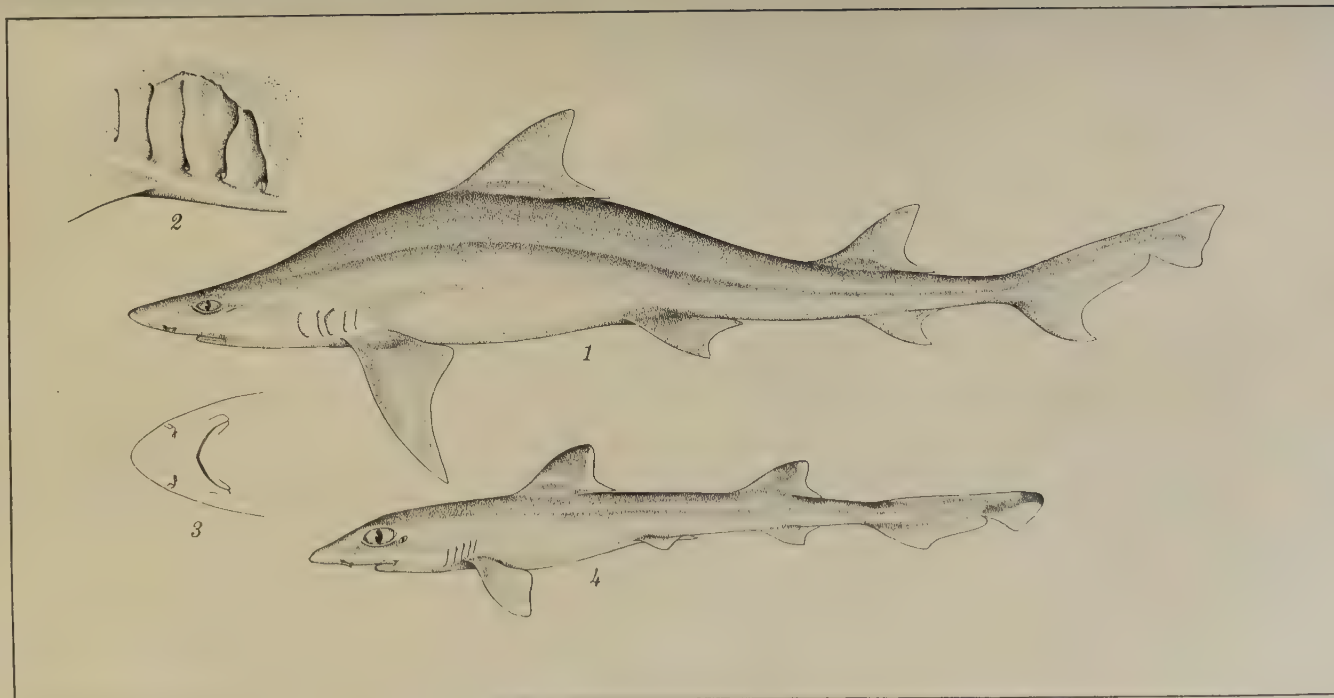

PLATE 1. HEMITRIAKIS LEUCOPERIPTERA G. ET SP. NOV.

A NEW PHILIPPINE PAUSSID, SYNONIMICAL NOTES ON PACHYRRHYNCHUS, AND A NEW SPECIES OF THE LATTER

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ONE TEXT FIGURE

Cerapterus herrei sp. nov.[1] Text fig. 1.

Related to *C. latipes* Swederus. Head, antennæ, pronotum, and legs black. Elytra shining black, broader than pronotum, at apical third with an irregular, dentate, yellowish, rufescent patch. This marking is larger and of different shape than that in *C. latipes.* Head, front smooth toward vertex, irregularly rather densely asperate or rugose and finely setose. Antennæ, first joint with rather coarse and irregularly scattered asperities and also more strongly setigerous. Second to ninth joints finely setose, particularly at outer margins. Pronotum strongly asperate at anterior margin, otherwise smooth, with a feebly pronounced, elongate depression at middle, the margins with a setose fringe. Legs scatteringly punctate and finely setose.

FIG. 1. *Cerapterus herrei* sp. nov.

Length, 13.8 millimeters.

MINDANAO, Lanao Province, Sacred Mountain, near Camp Keithley (*A. W. Herre*). Type in the collection of the Bureau of Science, Manila.

I name this interesting species in honor of its collector, who found it under some loose bark. From the same tree Doctor Herre collected a species of ant, *Polyrhachis bihamata* Drury, but whether the paussid has any relation to this formicid or not I am unable to say.

[1] Still another paussid (*Paussus catocanthus*) was lately described by Gestro, Boll. della Soc. Ent. Ital. 55 (1923) 5.

NOTES ON PACHYRRHYNCHUS

During January, 1923, I received upon request, through the kindness of Mr. G. J. Arrow, certain species of *Pachyrrhynchus* which have been compared with the types in the British Museum, together with several undetermined *Metapocyrtus* species.

The *Pachyrrhynchus* species are the following:

Pachyrrhynchus venustus Waterhouse.
Pachyrrhynchus rufopunctatus Waterhouse.
Pachyrrhynchus latifasciatus Waterhouse.
Pachyrrhynchus schoenherri Waterhouse.
Pachyrrhynchus inclytus Pascoe.

Unfortunately, none of the specimens bears any locality except "Philippines." A careful examination of the above specimens gave the following results:

Pachyrrhynchus schoenherri Waterhouse is, in general form, related to *P. erichsoni* Waterhouse, but is easily distinguished from the latter by the different general color and the location of the spots on the elytra, particularly a bifid sutural spot behind the middle and another bifid sutural spot near the apex.

Pachyrrhynchus inclytus Pascoe has been recognized by me in an earlier paper[2] as being identical with *P. modestior* Behrens. Professor Heller in 1912 also suspected this to be the case, but it was not until now that I could convince myself conclusively of this fact. The typical specimen of *P. inclytus* Pascoe from the British Museum differs slightly from the commoner forms of *P. inclytus* Pascoe; it has, in the middle of the elytra near the suture, as well as between the first and second longitudinal stripes, some spots which appear as a rudimentary crossband. In the usual form, which may be designated *P. inclytus* var. *modestior* Behrens, the spots are wanting. Behrens also mentioned the typical form of *P. inclytus*, calling it *P. modestior* var. γ. Heller[3] in 1921 described still another variation, *P. modestior* var. *transversatus*. This variation as described merely represents a combination of the characters of *modestior* var. β and var. γ Behrens.

Pachyrrhynchus latifasciatus Waterhouse is an isolated species and very distinct from the other members of the genus.

Under the name *Pachyrrhynchus venustus* Waterhouse not less than three distinct species have been confounded, probably

[2] Philip. Journ. Sci. 21 (1922) 577. [3] Philip. Journ. Sci. 19 (1921) 544.

due to lack of sufficient properly preserved material and the great similarity in the general appearance of the species involved. The typical specimen of *P. venustus* from the British Museum before me agrees perfectly with the original description of Waterhouse and, furthermore, is identical with my Mindanao species *P. virgatus* Schultze,[4] of which I have numerous perfect examples. *Pachyrrhynchus venustus* and *P. rufopunctatus* Waterhouse are not identical; Waterhouse was certainly correct in considering them as nearly related but distinct species. The typical specimen of *P. rufopunctatus* Waterhouse before me also agrees very well with the original description. I received several specimens of these species from Polillo. The confusion concerning *P. venustus* was started by Behrens[5] in 1887. This author identified *P. rufopunctatus* and another species (which was then and is still undescribed) as *P. venustus*, but he evidently did not have the latter at all. The following extract from his description clears up this point:

> In der Sammlung des Ersten findet sich ein einzelnes Stück mit flacherer Rüsselgrube, länglicheren, hinten weniger verschmälerten Flügeldecken, auf denen zarte Punktstreifen angedeutet sind und 22 lilafarbige Schuppenflecken stehen (ein weiterer zwischen den beiden Basalflecken). Dieses Stück dürfte wahrscheinlich nur eine Varietät des *P. venustus* sein. Nach Waterhouse variirt die Fleckenzahl auf den Flügeldecken zwischen 16 und 22, vielleicht haben die ♂ weniger Flecken als die ♀. Die Art *P. rufopunctatus* Waterh., die *P. venustus* sehr nahe stehen soll, und deren Diagnose bei Waterhouse * mit der von *P. venustus* gleichlautet, wird wohl nur eine leichte Varietät dieser Art darstellen.
>
> * *P. venustus*. Niger, laevis; capite macula una inter oculos; thorace maculis duabus supra, maculaque una ad utrumque marginem, elytris viginti-duabus ovatis ornatis; his e squamis auratis, vel aureo-cupreis, effectis.
>
> *P. rufopunctatus*. Niger, laevis; capite maculis tribus; thorace maculis duabus supra, maculaque una ad utrumque marginem, elytris vigintiduabus ornatis, his maculis e squamis rufis effectis.

It is clear from a comparison of the above descriptions by Waterhouse which Behrens quotes, that the two diagnoses are not identical, contrary to Behrens's assumption and interpretation. *Pachyrrhynchus venustus*, which he characterizes as having "22 lilafarbige Schuppenflecken," is a new species, which I shall describe below as *P. confusus* sp. nov.

In 1911 Professor Heller identified specimens from our collection, the species with the "lilafarbige" spots, as *P. venustus*

[4] Philip. Journ. Sci. 15 (1919) 549, pl. 1, fig. 1.

[5] Stett. Ent. Zeitg. 48 (1887) 251–253.

* Waterhouse, Trans. Ent. Soc. III, p. 310, 311.

Waterhouse, and in his determination table for the *Pachyrrhynchus* species describes it as follows:[6]

> Flügeldecken schwarz mit rötlichen, blass lilafarbigen, oder weisslichen Makeln.. P. venustus Waterh.

From this it is clear that he also was mistaken with respect to this species. In 1918, on the strength of the determination of Professor Heller, I published some biological notes on the false *Pachyrrhynchus venustus*,[7] and in 1922 I figured the penis structure,[8] also under the wrong name. The following remarks will serve to clear up matters concerning the above species of *Pachyrrhynchus:*

Pachyrrhynchus venustus Waterhouse.

Pachyrrhynchus venustus WATERHOUSE, Proc. Ent. Soc. London (1841) 18; Trans. Ent. Soc. London I 3 (1843) 310; Ann. Mag. Nat. Hist. I 8 (1842) 218; BOHEM., Schönh. Gen. Curc. VIII 2 (1844) 381.

Pachyrrhynchus virgatus SCHULTZE, Philip. Journ. Sci. 15 (1919) 549, pl. 1, fig. 1, ♀; ibid. 21 (1922) 593, pl. 3, fig. 7.

This species is shiny black and the elytra are impunctate. The scale spots are reddish or coppery golden metallic, and in fresh specimens are strongly opalescent. The spots laterad on the prothorax are roundish, not oblong-oval. The number of spots on the elytra is variable, as in the other related species.

MINDANAO, Surigao Province. DINAGAT.

Pachyrrhynchus venustus subsp. **insulanus** Schultze.

Pachyrrhynchus virgatus subsp. *insulanus* SCHULTZE, Philip. Journ. Sci. 15 (1919) 550.

This subspecies is uniform black and is known only from Siargao and Bucas Grande Islands.

Pachyrrhynchus rufopunctatus Waterhouse.

Pachyrrhynchus rufopunctatus WATERHOUSE, Proc. Ent. Soc. London I 4 (1842) 45; Trans. Ent. Soc. London I 3 (1843) 311.

Pachyrrhynchus venustus BEHRENS, Stett. Ent. Zeitg. 48 (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307.

Black, moderately shiny, the elytra impunctate and very finely rugose. The scale spots are reddish. The spots on the prothorax are oblong-oval.

POLILLO (*W. Schultze*).

[6] Philip. Journ. Sci. § D 7 (1912) 307.

[7] Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10 and 11.

[8] Ibid. 21 (1922) 593, pl. 3, fig. 2.

Pachyrrhynchus confusus sp. nov.

> *Pachyrrhynchus venustus* BEHRENS, Stett. Ent. Zeitg. 48 (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307; SCHULTZE, Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10 and 11; ibid. 21 (1922) 593, pl. 3, fig. 2.

Black, shiny, the elytra very finely rugose, with indistinct interrupted longitudinal rows of punctures. The scale spots very pale lilac, in old specimens sometimes whitish. Rostrum evenly but scatteredly punctate, basal half with an oblong depression and a longitudinal medial groove. Front with a squarish scale spot, and another smaller one, below the eyes. Prothorax as long as broad, the greatest width at the middle, finely and scatteredly punctate. Laterally, in the middle between the anterior and posterior margin, an oblong-oval spot. At each lateral margin, another, larger scale spot. Each elytron with two large oblong-oval basal spots, one discally, the other laterally; sometimes a small roundish spot is located between the two. Three other spots before the middle, of which the one located at the lateral margin is very oblong reaching backward beyond the middle. On the apical third another cross row of two or three spots and a triangular spot at the apex. Aside from the aforementioned spots each elytron bears a sutural spot at the middle and another on the apical fourth. Apical sutural termination of the elytra obtusely pointed in the female.

Male, length, 16 millimeters; width, 6.5. Female, length, 17.3 millimeters; width, 7.5.

LUZON, Laguna Province, Los Baños (*W. Schultze*). In a swamp, feeding on the fern *Acrostichum aureum* Linn.

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ILLUSTRATION

NIGHT AND DAY RATES OF ELONGATION OF BANANA LEAVES[1]

By Sam F. Trelease

Of the Johns Hopkins University, Baltimore, Maryland

It is well known that the aërial parts of plants usually enlarge faster at night than in the daytime, if the temperature remains about the same. Growing plant organs may even shrink during the day instead of elongating. An example of this may be taken from the results of a study of growth in *Cestrum nocturnum,* made by Brown and Trelease.[2] It was found that the young shoots wilted and actually shortened during periods of exposure to direct sunlight on dry days, but that they elongated rapidly at night; they showed no elongation in the daytime excepting in the late afternoon, after they had returned to their early morning length. Measurable enlargement depends principally upon an increase in the water content of enlarging cells. The fact that the growth rate is usually higher for the night than for the day is apparently related to a higher water content of the plant as a whole in the night;[3] it is at least safe to suppose that it depends upon a higher night water content of the enlarging cells.

The present paper aims to illustrate, by means of a series of measurements, the relative elongation rates of leaves of a banana [*Musa sapientum* Linn. var. *cinerea* (Blanco) Teod.], locally known as *latundan,* by day and by night, and to present some observations on variations in leaf position that appear to be related to corresponding variations in foliar water content.

[1] Botanical contribution of the Johns Hopkins University, No. 73.

[2] Brown, W. H., and Trelease, S. F., Alternate shrinkage and elongation of growing stems of Cestrum nocturnum, Philip. Journ. Sci. § C 13 (1918) 353–360.

[3] Livingston, B. E., and Brown, W. H., Relation of the daily march of transpiration to variations in the water content of foliage leaves, Bot. Gaz. 53 (1912) 309–330; Lloyd, F. E., Leaf water and stomatal movement in Gossypium and a method of direct visual observation of stomata in situ, Bull. Torrey Bot. Club 40 (1913) 1–26; Shreve, Edith B., The daily march of transpiration in a desert perennial, Carnegie Inst. Washington Pub. 194 (1914).

The study was made in 1919, during the latter part of the dry season (May), at the College of Agriculture, Los Baños, Laguna, Philippine Islands. It is a pleasure to acknowledge indebtedness to Prof. B. E. Livingston for suggestions in the preparation of this paper, and to Mr. Felix Maceda for assistance in securing the measurements.

LEAF ELONGATION

The leaf elongation of ten selected plants was measured at 6 a. m. and at 6 p. m., for five days. The method used was based on that described by Copeland [4] for measuring leaf enlargement of the youngest visible leaf of the coconut. A transverse line was drawn with ink across the bases of the youngest leaf (leaf 1) and the next to the youngest leaf (leaf 2) where the latter overlapped the former, about half of the line being on each leaf. Since the two adjacent leaves do not elongate at the same rate, the two parts of this line are soon shifted with reference to each other, one leaf sliding upon the other as growth proceeds. At the end of the twelve-hour period the vertical distance between the two parts of this line showed the difference in elongation between the two leaves. A similar line drawn across the bases of leaf 2 and the next older leaf (leaf 3) was used to measure the difference in elongation between these two leaves. Older leaves were marked and observed similarly, it being assured that the oldest leaf considered had already ceased to elongate at the time of marking. The sum of all the differences thus shown was taken as a measure of the elongation of the youngest leaf, for the period.

It is evident that if a represents the distance between the two line parts for leaves 1 and 2, b the corresponding distance for leaves 2 and 3, c the distance for leaves 3 and 4, d the distance for leaves 4 and 5, etc., then the entire elongation of leaf 1 is measured by the sum $a + b + c + d + \ldots\ldots + l$, in which l represents the measured distance for the oldest pair of leaves showing any measurable shifting of the line parts. Similarly, the growth of leaf 2 is given by $b + c + d + \ldots\ldots + l$; of leaf 3, by $c + d + \ldots\ldots + l$; of leaf 4, by $d + \ldots\ldots + l$; and, finally, of leaf n, by l, there being n elongating leaves. The elongation of all visible leaves taken together is represented by the sum of the series $a + 2b + 3c + 4d + \ldots\ldots + nl$. Although the enlargement of the youngest visible leaf repre-

[4] Copeland, E. B., The Coco-nut. London, Macmillan and Co. (1914) 212.

sented such a large proportion of the total leaf elongation that it alone might have been used as a close approximation of that total, nevertheless it was considered advisable in the present tests to employ the total elongation of all visible leaves.

It must be mentioned here that the method just described fails to take into account the growth of the young leaves before they make their appearance above the false trunk, composed of overlapping leaf bases. This method is, however, the one which may be most satisfactorily applied to the growth of banana and abacá plants.

The results of these measurements are given in Table 1, which shows the day and following night increments of total leaf elongation of the ten banana plants, for the five consecutive days, May 14 to May 18, inclusive. The table also shows the total twenty-four-hour increment, and the ratio obtained by dividing the night increment by the preceding day increment.

In spite of the great variability of the different plants during the same day and of the same plant during the different days, the data shown in Table 1 illustrate the outstanding fact that, as is true of most plant organs which have been studied in this respect, these banana leaves usually elongated much more during the night than during the day, this fact being brought out by the records of individual plants as well as by the averages for each day. As shown in Table 1, the average ratios of night elongation to preceding day elongation for these five days were 1.7, 5.5, 1.5, 2.5, and 3.3. The highest ratio value for the whole series was 32.0, for plant 4 on May 15 to 16 (the ratio for plant 3 on May 18 to 19 has no meaning, since there was no measurable elongation during the day), and the lowest ratio value was 0.2. For the first day, eight of the ten plants showed greater elongation during the night than during the day, one showed less, and one the same as during the day. For the second day, nine plants showed greater elongation during the night, and one showed less. For the third day, however, only six plants showed greater elongation at night, and four showed less than during the day. For the fourth day, eight plants showed greater elongation during the night and two showed less than during the day. For the fifth day, seven plants showed greater elongation during the night, two showed less, and one the same as during the day.

Turning to the day and night rates themselves and to the total twenty-four-hour rates, attention should be called to plant

TABLE 1.—*Day and following night increments of total leaf elongation of ten banana plants, in the open and unshaded, for five consecutive days.*

Plant.	First day, May 14–15.				Second day, May 15–16.			
	Day period.	Night period.	Total.	Ratio night to day.	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*	
1	9.2	11.5	20.7	1.3	1.9	7.8	9.7	4.1
2	1.3	1.3	2.6	1.0	0.8	1.1	1.9	1.4
3	0.4	0.9	1.3	2.3	0.2	0.7	0.9	3.5
4	0.8	1.6	2.4	2.0	0.1	3.2	3.3	32.0
5	2.7	4.3	7.0	1.6	2.5	3.6	6.1	1.4
6	5.8	3.6	9.4	0.6	2.5	4.3	6.8	1.7
7	1.5	3.4	4.9	2.3	1.1	3.9	5.0	3.5
8	1.6	2.1	3.7	1.3	2.4	2.1	4.5	0.9
9	0.8	1.9	2.7	2.4	0.8	4.1	4.9	5.1
10	3.2	6.9	10.1	2.2	2.4	3.3	5.7	1.4
Average	2.7	3.8	6.5	1.7	1.5	3.4	4.9	5.5

Plant.	Third day, May 16–17.				Fourth day, May 17–18.			
	Day period.	Night period.	Total.	Ratio night to day.	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*	
1	3.9	5.8	9.7	1.5	1.1	3.9	5.0	3.5
2	0.8	0.6	1.4	0.8	0.2	1.1	1.3	5.5
3	0.4	1.4	1.8	3.5	0.3	0.9	1.2	3.0
4	4.5	2.2	6.7	0.5	0.7	0.9	1.6	1.3
5	4.6	1.8	6.4	0.4	4.7	7.7	12.4	1.6
6	4.3	3.0	7.3	0.7	1.1	2.5	3.6	2.3
7	3.7	3.9	7.6	1.1	0.5	1.9	2.4	3.8
8	1.2	1.6	2.8	1.3	0.9	2.3	3.2	2.6
9	0.5	1.9	2.4	3.8	1.1	0.7	1.8	0.6
10	1.3	2.1	3.4	1.6	1.5	1.3	2.8	0.9
Average	2.5	2.4	5.0	1.5	1.2	2.3	3.5	2.5

Plant.	Fifth day, May 18–19.			
	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*	
1	5.8	1.1	6.9	0.2
2	0.7	7.7	8.4	11.0
3	0.0	0.2	0.2	------
4	2.1	13.4	15.5	6.4
5	36.0	49.3	85.3	1.4
6	5.7	14.4	20.1	2.5
7	0.3	1.3	1.6	4.3
8	0.3	1.5	1.8	5.0
9	3.3	2.2	5.5	0.7
10	2.9	2.9	5.8	1.0
Average	[a] 2.3	[a] 5.0	[a] 7.3	3.3

[a] Average derived from data for only nine plants, the value for plant 5 being disregarded.

5 for the fifth day, in which case the rates are clearly very exceptional. No special explanation for the exceedingly high rates of this plant for that day is suggested; and the day, night, and twenty-four-hour values for plant 5 have been disregarded in the computation of the average rates for the fifth day. In all other cases the daily averages given in Table 1 are derived regularly.

The mean increments in elongation for the five night periods were 3.8, 3.4, 2.4, 2.3, and 5.0 centimeters, respectively; for the preceding day periods they were 2.7, 1.5, 2.5, 1.2, and 2.3 centimeters, respectively; and for the twenty-four-hour periods they were 6.5, 4.9, 5.0, 3.5, and 7.3 centimeters, respectively. Aside from the exceptional case just mentioned, the greatest total leaf elongation for the twelve-hour nocturnal period was 14.4 centimeters (plant 6, fifth day), the greatest for the diurnal period was 9.2 centimeters (plant 1, first day), and the greatest for the twenty-four-hour period was 20.7 centimeters (plant 1, first day). The smallest elongations were 0.2 centimeter for the nocturnal, zero for the diurnal, and 0.2 centimeter for the twenty-four-hour period.

Although these rates of elongation may be considered as representative of what may be expected for banana leaves under environmental conditions similar to those here dealt with, the growth rate must in general be more or less markedly influenced by the climatic conditions (generally grouped as climate, season, and weather), as well as by the internal conditions of the plant (usually grouped as the variety of plant; its tone, or health condition; and its phase of development). The pronounced variation shown in the elongation rates given in Table 1 may possibly have been due to corresponding variations in the environmental conditions, or they may have been directly related to internal variability among the plants themselves. Both groups of conditions may of course have been influential together.

An attempt was made to find out whether the growth data contain any evidence of influential differences between the external conditions of the several days. The question is, do the five days group themselves as good, poor, etc., for leaf elongation as indicated by the whole group of plants taken together? One way to approach this question is simply to examine the averages. Table 2 presents the five daily averages for each of the four kinds of data, each series of averages arranged in the descending order of magnitude.

TABLE 2.—*Nocturnal, diurnal, and twenty-four-hour average rates of leaf elongation for each of the five days, arranged in the descending order of magnitude in each case.*

Nocturnal averages.		Diurnal averages.		Total averages.		Ratio, night to preceding day.	
	cm.		*cm.*		*cm.*		
Fifth day	5.0	First day	2.7	Fifth day	7.3	Second day	5.5
First day	3.8	Third day	2.5	First day	6.5	Fifth day	3.3
Second day	3.4	Fifth day	2.3	Third day	5.0	Fourth day	2.5
Third day	2.4	Second day	1.5	Second day	4.9	First day	1.7
Fourth day	2.3	Fourth day	1.2	Fourth day	3.5	Third day	1.5

It is seen from Table 2 that, judging by the three average rates, the first day appears to have been generally much better for leaf elongation than was the fourth. The fifth day was apparently about as good as the first. It seems unsafe to attempt any more-detailed suggestions from these averages.

Another way to approach the same question was also tried. Each of the three series of elongation increments (fifty in each series) was arranged in the descending order, each value being accompanied by the number of the day in which it was obtained. Then the distributional frequency of the several day numbers was studied for the upper and the lower portion of each series. In all three series, day 4 had high frequencies among the low rate values and very low frequencies among the high values. The frequencies of the five day numbers were otherwise without suggestion in this connection. There was no evidence that the first day had exceptionally high values.

From these results it appears that the evidence is fairly strong that the conditions of the fourth day were characterized as poor for leaf elongation, with the added suggestion that possibly those of the first day were peculiarly good.

TABLE 3.—*Climatic data for period of growth measurements.*

Date.	Rainfall.	Temperature.		
		Maximum.	Minimum.	Mean.
	mm.	°*C.*	°*C.*	°*C.*
May 14	7.7	33.5	23.1	28.3
May 15	0.9	33.0	23.6	28.3
May 16	0.0	34.0	24.1	29.0
May 17	3.6	33.2	23.6	28.4
May 18	1.5	33.0	23.6	28.3
May 19	5.0	34.5	24.1	29.3

Data of rainfall and temperature for the days during which measurements were made are given in Table 3; but these data are not sufficient to allow any close comparison between them and the growth data, no clear relations being apparent. These climatic values indicate that the five days considered were very much alike with respect to the two main weather conditions usually employed in climatology.

As far as the available information goes, it is necessary to say that some portion of the variation shown in Table 1 was probably related to differences in the environmental conditions of the several days, but it is impossible to suggest just what conditions were thus effective, or to what degree. Certainly a large part of the variation was due to internal differences among the plants, differences within the plant body and not related to simultaneous differences in the surroundings.

Individual variation among apparently similar plants constitutes one of the greatest difficulties in the interpretation of the results of physiological studies. This is perhaps the most important question in the whole of plant physiology to-day, and it will probably remain so until we are able to obtain a group of plants that will agree within a small range of variation. Since the rates of elongation of these banana plants form a good example of individual variation, it appears important to call attention to the degree of variability that they exhibited.

It is seen at once from the data of Table 1 that the ten plants, selected as apparently alike, differed very greatly among themselves with reference to the total increment of leaf elongation for the same twenty-four-hour period, with reference to their day and night increments for the same day and night periods, and also with reference to the ratio of night increment to preceding day increment for the same day. These data illustrate the very high degree of variation that may be expected in a group of such plants, even when they appear by visual observation to be alike, and when all seem to have the same exposure. Averages based upon variables having such wide deviation are plainly not reliable unless properly understood; and the conclusions drawn from these data must of course be based upon a consideration of the variability exhibited.

The data of Table 1, just discussed, illustrate the great variability among the different plants during the same periods—that is, during each of the five days when measurements were made. It seems important to determine, also, how the plant

variability differed from day to day. If, for example, on one day a certain plant shows a very great increment, as compared with the increments of the other plants, does it show high relative increments on the other days? An answer to this question is brought out in Table 4, which shows the increments of total leaf elongation for each plant for each twenty-four-hour period, each increment being expressed as a percentage of the average increment for all plants for that day.

TABLE 4.—*Increments (for each of the five days) in leaf elongation for the twenty-four-hour period, these increments being expressed as percentages of the average of the ten plants for the day.*

Day.	Plant 1.	Plant 2.	Plant 3.	Plant 4.	Plant 5.	Plant 6.	Plant 7.	Plant 8.	Plant 9.	Plant 10.
First	319	40	20	37	108	145	75	57	42	155
Second	198	39	18	67	125	139	102	92	100	116
Third	194	28	36	134	128	146	152	56	48	68
Fourth	143	37	34	46	354	103	69	91	51	80
Fifth	95	115	3	212	([a])	275	22	24	75	79
Minimum	95	28	3	37	108	103	22	24	42	68
Maximum	319	115	36	212	354	275	152	92	100	155

[a] Omitted; see Table 1.

Table 4 shows that from day to day there was great variation in the relative rates of elongation; a plant may on one day show leaf elongation much below the average for all plants on that day, while on another day it may show an elongation greatly above the average. Thus it would be impossible to standardize each of these plants on one day and to predict their relative increments on a succeeding day. It is true that plants 2 and 3 always gave a relatively small daily increment, and that plants 1, 5, and 6 gave relatively high increments on most days; but their relative increments were not at all constant, and other plants varied, during the five-day period, from very low to very high relative increments.

In order to bring out possible relationships among the four different kinds of plant data, the data of Table 1 were rearranged to form a new table, in which the first vertical column gave the growth increments in a descending series, beginning with the largest day increment and ending with the smallest day increment. The table was then completed by placing in the second, third, and fourth columns, respectively, the night increment, the twenty-four-hour increment, and the ratio of the night increment to the day increment, corresponding to each of the day increments in the first column. The values in each

column were then separated into five groups, of ten each, and the average for each group was calculated. The averages are presented in Table 5. Besides the actual averages of the five groups of values, the table also shows the relative values of these averages, each expressed in terms of the uppermost one considered as 100.

TABLE 5.—*Relationships among data representing diurnal increment, nocturnal increment, twenty-four-hour increment, and ratio of nocturnal increment to diurnal increment; actual averages are given for each kind of data, and also values relative to the first in each column.*

Group of values, by diurnal increments.	Diurnal increment.		Nocturnal increment.		Twenty-four-hour increment.		Ratio, nocturnal to diurnal.	
	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.
	cm.		*cm.*		*cm.*			
Highest ten [a]	5.39	100	5.68	100	11.07	100	1.03	100
Second ten	2.77	51	4.69	83	7.46	67	1.84	179
Third ten	1.36	25	2.81	49	4.17	38	2.01	195
Fourth ten	0.79	15	2.46	43	3.25	29	3.27	318
Lowest ten [b]	0.30	6	1.43	25	1.73	16	6.99	679

[a] Really the highest 9; see Table 1. [b] Really the lowest 9; see Table 1.

From Table 5 it is at once seen that progressively lower values of the day increment correspond to correspondingly lower values of the night increment and also of the twenty-four-hour increment. On the other hand, progressively lower values of the day increment correspond to progressively higher values of the night-day ratio. The range is greater and the differences are greater for the day increment than for the night increment. In a general way, night increments and twenty-four-hour increments vary directly with day increments, while ratios vary inversely with day increments. An explanation of the inverse relationship between the ratio values and the values for each of the three increments lies in the fact that the change in day increments is much more pronounced than the change in night increments, which remain relatively constant. The same approximate relationships suggested by the arrangement of all the data in the series just described are brought out by an examination of the records of the individual plants, showing the fluctuations from period to period in the rates of elongation.

LEAF POSITION

The two halves, right and left wings, of the banana leaf lie in nearly the same plane at night, like the right and left halves

of an ordinary flat leaf; but some wilting generally occurs in the day, and the two wings swing downward, about the midrib as an axis, so that their lower faces approach each other as wilting begins and progresses. These changes in leaf position are principally due to alterations in the turgidity of the cells in a double "hinge," composed of two narrow, colorless strips of tissue visible on the lower surface of the leaf, one along each side of the midrib for its entire length. By the action of the hinge, the two wings assume various positions, swinging upward or downward as if hinged to the midrib. The magnitude of the angle between the two wings may be approximated by determining the distance between the two free edges of the leaf; this distance may be called the apparent leaf width.[5] The apparent leaf width would become zero if the leaf were completely closed, which does not occur, however, in the case of banana leaves. Fluctuations in the apparent leaf width are probably approximate indices of corresponding fluctuations in the turgidity of the hinge cells, and these changes are probably primarily determined by the water content of these cells. The leaf movements may therefore be considered as indices of changes in foliar water content.

A study was made of the angular changes in the leaf wings, using forty-six selected leaves exposed to full sunlight, the apparent width of each leaf being measured every two hours, from 8 a. m. to 6 p. m., May 17. An equal number of similar leaves that were partly shaded during the day were also measured in the same manner. The averages of the values secured are shown in Table 6. The actual averages are given and also the corresponding relative values, the latter being expressed, for each series, as percentages of the actual value for 8 a. m.

An examination of the data of Table 6 shows that in each set the apparent width of the leaves decreased from 8 a. m. until noon, and then increased until 6 p. m. This may be taken to mean that the turgidity, and presumably the water content, of the hinge cells decreased until about noon and then increased in the afternoon. The reversible movements of the wings of these leaves are apparently due to alterations in the moisture content of the thin-walled hinge cells that lie in a row at each

[5] The trigonometrical reasoning on which this statement is based has been presented in another paper. See Trelease, Sam F., Incipient drying and wilting as indicated by movements of coconut pinnae, Am. Journ. Bot. 9 (1922) 253–265.

TABLE 6.—*Diurnal fluctuations in apparent leaf width for banana plants, each value representing the average for forty-six leaves, on May 17, 1919.*

Time of observation.	Leaves in sun.		Leaves in partial shade.	
	Actual.	Relative.	Actual.	Relative.
	cm.		*cm.*	
8 a. m.	21.7	100	25.0	100
10 a. m.	16.7	77	23.7	95
12 noon	7.4	34	19.4	78
2 p. m.	17.3	80	23.1	92
4 p. m.	20.1	93	24.4	98
6 p. m.	22.2	102	25.1	100

side of the midrib, the hinge cells apparently changing readily in shape or size or both, with even slight changes in their water content. The hinge cells appear to be peculiarly sensitive to changes in the water content of the leaf or of the plant as a whole, resulting from alterations in the relation between the rate of transpiration and the rate of water absorption by the roots. A water deficit, or a state of incipient drying, in a part or in all of the plant tissue may be expected to follow periods during which the transpiration rates have exceeded the rates of absorption. While the hinge cells appear to be particularly sensitive to water deficit, the water content of the plant as a whole probably follows, in a general way at least, the changes in water content of these cells. The results presented in Table 6 thus indicate that the leaves were nearly completely saturated with water at 8 a. m., and that after that hour the water content decreased progressively, reaching a minimum value some time between 10 a. m. and 2 p. m. The time of minimum apparent leaf width occurs somewhere within a period somewhat less than two hours; it may have occurred, as far as these measurements show, at almost any time between 10 a. m. and 2 p. m., although the minimum average reading was obtained at noon. Whenever this minimum actually occurred in this particular case, other observations on banana plants have shown that its time of occurrence differs, even for the same plant, for different days. This has also been found to be true in the case of the coconut. It will be noted that, as would be expected, the set of leaves exposed to full sunlight showed a much greater change than did those that were partially shaded, thus indicating a less-pronounced water deficit in the shaded leaves. By 6 p. m.

the leaves had apparently recovered the degree of saturation which they had had at 8 a. m. Other observations of banana plants showed that, although maximum expansion of the leaf wings usually occurred shortly after sunset, the plant as a whole became more turgid later in the night, this being indicated by increasing rigidity and elevation of the leaf midribs, as well as by a slightly greater diameter of the false trunk composed of overlapping leaf bases. The maximum expansion of the leaf wings was maintained throughout the night, and the wings began to approach each other again soon after sunrise on the succeeding day.

It appears that the turgor movements of such leaves as those of the banana furnish an index of leaf turgidity, and hence of leaf water content. If this be true, then the apparent leaf width might be an index of the rate of leaf elongation; and it might be possible, by employing this index, to relate the difference between the nocturnal and diurnal elongation rates, discussed in the first part of this paper, to corresponding differences in turgor. As is well known, enlargement does not take place in plant cells that are not turgid; enlargement requires an excess in the rate of water intake, above that of water loss. It is suggested that the two groups of phenomena dealt with in this paper may be closely related through the same causal condition, turgidity. But the experimental observations for growth rates and for leaf movements were not made for the same periods, and hence no direct evidence is available in this respect.

POTASSIUM FERROCYANIDE AS A REAGENT IN THE MICROSCOPIC QUALITATIVE CHEMICAL ANALYSIS OF THE COMMON ALKALOIDS

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TWO PLATES

The division of organic chemistry of the Bureau of Science is often called upon to determine the presence or absence of habit-forming drugs in minute amounts of material, such as a drop of liquid clinging to a syringe or a grain or two of powder in an otherwise empty container. Obviously, color tests are not feasible in such cases and recourse is had to microchemical reactions by which many tests can be made upon an exceedingly small amount of sample.

Descriptions of these tests are scattered throughout the literature. Wormeley's[1] classic on the microchemistry of poisons contains many tests and beautiful etchings. The various types of crystals formed by the reaction of such standard reagents as platinum or gold chloride are well known, but not so much attention has been paid to some of the less-common reagents. Among these potassium ferrocyanide should hold a prominent place. Behrens,[2] Grutterink,[3] Stephenson,[4] and others mention the use of potassium ferrocyanide as a reagent, but none of them gives a complete list of the alkaloids yielding characteristic crystalline precipitates with this reagent. I have tested forty of the common alkaloids[5] with potassium ferrocyanide. By

[1] Wormeley, T. G., Micro-chemistry of Poisons ed. 2 (1885).

[2] Behrens, H., Anl. zur mikrochemishe Analyse 3 (1896).

[3] Grutterink, A., Zeitschr. Anal. Chem. 51 (1912) 175.

[4] Stephenson, C. H., Some Microchemical Tests for Alkaloids (1921).

[5] The alkaloids tested were: Aconitine, apomorphine, arecoline, atropine, berberine, β-eucaine, brucine, caffeine, cinchonidine, cinchonine, cocaine, codeine, coniine, curare, emetine, ergotinine, heroine, homatropine, hydrastine, hyoscyamine, morphine, narceine, narcotine, nicotine, novocaine, papaverine, physostigmine, pilocarpine, piperazine, piperidine, piperine, quinine, quinoline, scopalamine, sparteine, stovaine, strychnine, theobromine, theophylline, veratrine.

the methods mentioned below, thirteen of these (β-eucaine, brucine, cinchonidine, cinchonine, cocaine, coniine, heroine, hydrastine, quinoline, sparteine, strychnine, stovaine, and veratrine) give characteristic crystalline precipitates. Bolland[6] states that apoatropine and hydrocotarnine give crystalline plates with potassium ferrocyanide. Grutterink[7] includes tropococaine and cotarnine. Unfortunately these four alkaloids were unobtainable by me. The crystalline compounds obtained are of the addition type, and probably have the general formula[8] $B_2.H_4Fe(CN)_6.X\ H_2O$.

The sensitivity and the best method of applying the tests have also been determined.

TECHNIC

The alkaloid or alkaloidal salt to be tested is dissolved in distilled water acidified with dilute hydrochloric acid. A drop of this solution is placed upon a miscroscope slide. The drop should not be more than 2 to 3 millimeters in diameter. Close to this drop is placed a smaller drop of a 5 per cent aqueous solution of potassium ferrocyanide. By means of a platinum wire or drawn-out glass rod, a tiny channel is made to flow from the reagent into the test drop. Usually an amorphous precipitate results which gradually becomes crystalline. If no precipitate appears, or if the precipitate remains amorphous after a minute or two, the preparation is vigorously scratched with a platinum or glass rod. In fact, I have found that, generally speaking, much more characteristic and perfect crystals result upon scratching and upon the use of comparatively dilute alkaloidal solutions. The drop is examined under a low power. The color, shape, crystal angles, polarization, extinction angles, and habit aid in the identification of the crystals under examination.

The sensitivity was obtained by testing solutions of the alkaloid in decreasing concentration until one was reached that failed to give crystals with the reagent within five minutes. The most-dilute solution, one drop of which yields crystals within five minutes, gives the sensitivity. The dilution of the drop by the reagent solution must of course be taken into consideration.

[6] Bolland, A., Monatsh. 32 (1910) 120, 129.
[7] Grutterink, A., Zeitschr. Anal. Chem. 51 (1912) 175.
[8] Cuming, W. M., Journ. Chem. Soc. 121 (1922) 1287.

β-EUCAINE

Sensitivity, 1 : 200.

β-eucaine forms with potassium ferrocyanide in hydrochloric acid solution colorless, thin, elongated, hexagonal or rhombic plates. They tend to grow to a very large size but they remain very thin. Under crossed nicols they are weakly polarized, exhibiting parallel and symmetrical extinction. Scratching of the preparation to induce crystallization is necessary. Plate 1, fig. 1.

BRUCINE

Sensitivity, 1 : 2,500.

Brucine forms with potassium ferrocyanide in hydrochloric acid solution highly refractive, stocky prisms with chisel-shaped ends. Usually the prisms occur in rosettes. Under crossed nicols the crystals are strongly polarized, exhibiting parallel extinction. There is a tendency toward supersaturation, and scratching of the preparation is necessary. Plate 1, fig. 2.

CINCHONIDINE

Sensitivity, 1 : 300.

Cinchonidine in hydrochloric acid solution yields with potassium ferrocyanide rosettes of yellow, curving, hairlike needles (Plate 1, fig. 3) when the concentration of the alkaloid is over 0.5 per cent. At 1 : 300 long thin rectangular yellow plates, exhibiting parallel extinction under crossed nicols, form near the edge of the drop. Scratching or seeding aid in the crystal formation.

CINCHONINE

Sensitivity, 1 : 1,000.

Cinchonine forms with potassium ferrocyanide in hydrochloric acid solution yellow, irregular, trapesium-shaped crystals, often grouping in the form of rosettes. They polarize strongly. Cinchonine is readily distinguished from cinchonidine and quinine by this test. Quinine does not yield a crystalline precipitate, and cinchonidine yields either hairlike crystals or thin rectangular plates. Plate 1, fig. 4.

COCAINE

Sensitivity, 1 : 500.

Cocaine forms with potassium ferrocyanide in hydrochloric acid solution colorless, six-sided plates and prisms of irregular shape. They polarize strongly under crossed nicols. On edge

they exhibit parallel extinction. Scratching of the preparation is usually necessary to induce crystallization.

The crystals tend to grow much thicker, polarize more strongly, and are more irregular in shape than those from β-eucaine. They form much more readily than those from heroine and do not form the spheroidal type of crystal characteristic of the latter. Stovaine is also readily distinguished from cocaine by this test. Plate 1, fig. 5.

CONIINE

Sensitivity, 1 : 50.

Coniine yields with potassium ferrocyanide in hydrochloric acid solution rosettes of colorless needles and long, thin, square-ended prisms. Scratching aids in the formation of the crystals. Under crossed nicols the crystals polarize weakly, exhibiting oblique extinction. The extinction angle is rather large, about 30°. Plate 1, fig. 6.

HEROINE

Sensitivity, 1 : 50.

Heroine forms spheroidal crystals with potassium ferrocyanide in hydrochloric acid solution only when the concentration of the alkaloid is very high. These crystals often do not appear for five minutes. With vigorous scratching there are sometimes obtained hexagonal plates belonging to the hexagonal system. Plate 2, fig. 1.

HYDRASTINE

Sensitivity, 1 : 700.

Hydrastine forms with potassium ferrocyanide in hydrochloric acid solution white, spheroidal crystals. Isolated crystals are not present. The spheroids are polarized under crossed nicols. Plate 2, fig. 8.

QUINOLINE

Sensitivity, 1 : 800.

Quinoline yields with potassium ferrocyanide in hydrochloric acid solution lemon yellow rhombohedrons exhibiting parallel and oblique extinction. Scratching is unnecessary. The crystals are very characteristic. Plate 2, fig. 9.

SPARTEINE

Sensitivity, 1 : 2,000.

Sparteine yields with potassium ferrocyanide in hydrochloric acid solution characteristic, colorless rhombs exhibiting symmetrical extinction under crossed nicols. Scratching aids in the crystal formation. Plate 2, fig. 10.

STOVAINE

Sensitivity, 1 : 300.

Stovaine yields with potassium ferrocyanide in hydrochloric acid solution rosettes of needles usually radiating from a solid mass at the center. The individual crystals exhibit parallel extinction under crossed nicols. The crystals tend to form first at the edge of the drop. Plate 2, fig. 11.

STRYCHNINE

Sensitivity, 1 : 20,000.

Potassium ferrocyanide affords a very sensitive test for strychnine. In hydrochloric acid solution this reagent yields with strychnine long, slender needles, or spear-shaped crystals with serrated edges (Plate 2, fig. 12). Hemimorphic triangular plates are sometimes formed. Under crossed nicols the long crystals exhibit oblique extinction. When the concentration of the strychnine is high but very little reagent is added, the true form of the compound sometimes comes out on scratching. These are small rhombic plates exhibiting symmetrical extinction under crossed nicols.

VERATRINE

Sensitivity, 1 : 100.

The white amorphous precipitate obtained when potassium ferrocyanide is added to a hydrochloric acid solution of veratrine yields crystals only with great difficulty. The crystals formed are imperfect and might not be recognized if polarized light were not used. Under crossed nicols they polarize strongly. The test, however, is not a satisfactory one.

SUMMARY

1. Thirteen of forty of the common alkaloids yield crystalline precipitates with potassium ferrocyanide in hydrochloric acid solution. These precipitates are sufficiently characteristic to be used as corroborative identification tests.

2. The tests can be applied to very minute amounts of material.

3. Potassium ferrocyanide is a satisfactory microchemical reagent for the distinction of cinchonidine, cinchonine, and quinine.

4. Brucine and strychnine are readily distinguished by this reagent.

5. Cocaine can be distinguished from β-eucaine, stovaine, and heroine by the potassium ferrocyanide test.

6. The sensitivity of the potassium ferrocyanide test for the various alkaloids has been determined.

ILLUSTRATIONS

Crystals of alkaloids obtained with potassium ferrocyanide and hydrochloric acid. The figures 1 : 50, etc., signify the dilutions at which the respective crystals were produced. Magnification of microphotographs, × 50.

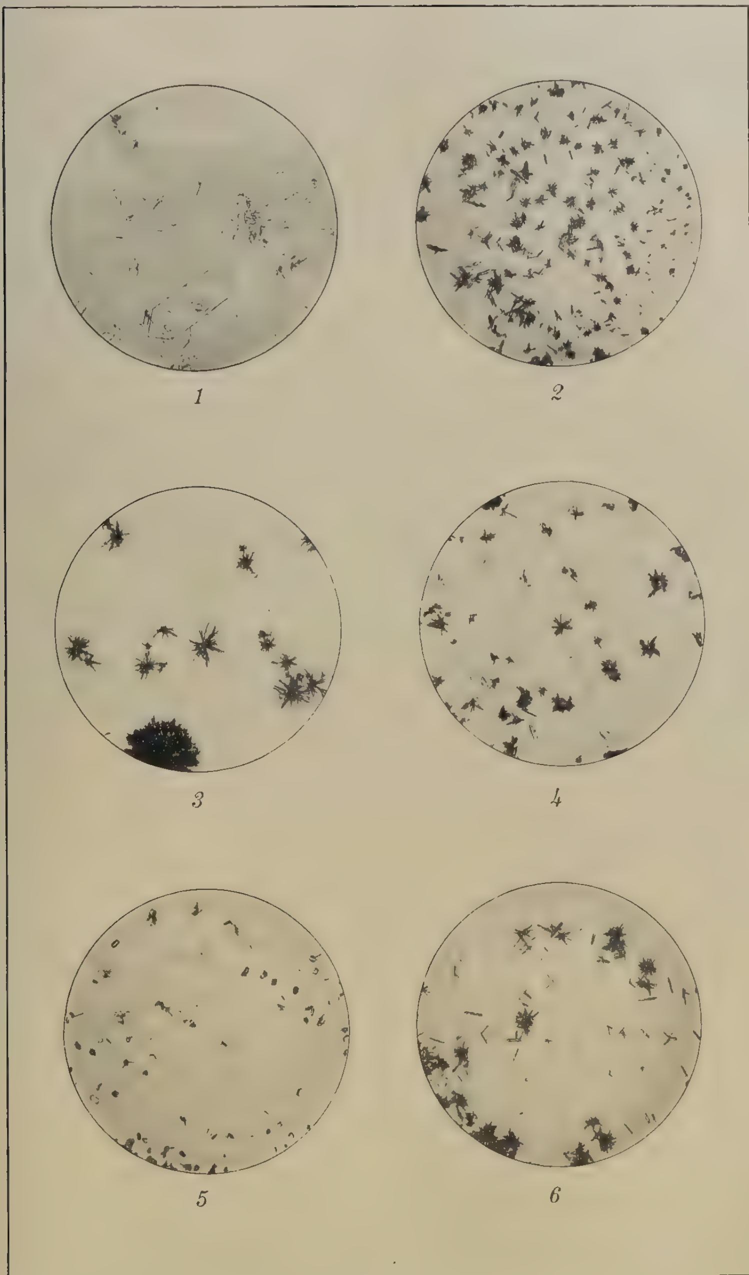
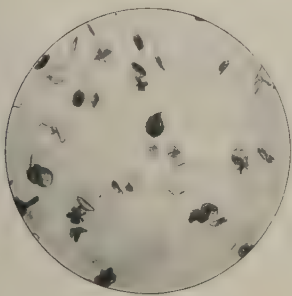


PLATE 1.



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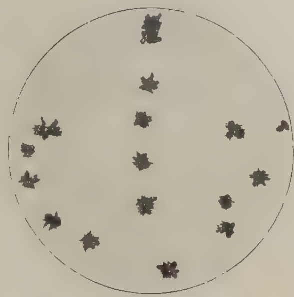

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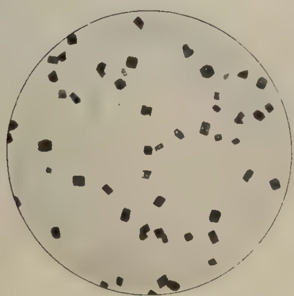

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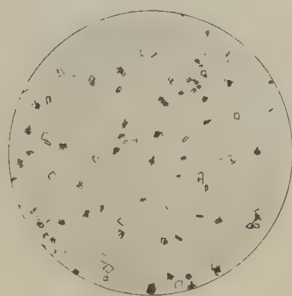

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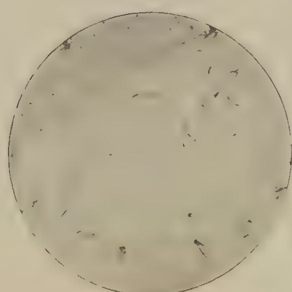

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PLATE 2.

HOOKWORM DISEASE: A CLINICAL ENTITY IN THE PHILIPPINE ISLANDS

By Charles N. Leach,[1] Benjamin Schwartz,[2] and Florence Dixon Leach

with the coöperation of

Frank G. Haughwout[3]

TWO PLATES AND ONE TEXT FIGURE

The observations recorded in this paper were made incidentally to a brief inquiry into the incidence of hookworm infestation in the country adjacent to the city of Cebu, Cebu Island, Philippine Islands (fig. 1). They are designed formally to record the existence of hookworm disease in the Philippines because, strangely enough, this appears not to have been done in the past. To a considerable degree, the failure to record its existence probably has been the result of preconceived ideas regarding the behavior of Filipinos under the influence of hookworm infestation that have been gained from data of an unconvincing nature. In justice to the medical men working in and about Cebu, it must be said that they have recognized the condition for many years. Moreover, it should be recalled that organized survey work in tropical diseases practically ceased in 1915, at which time more-accurate methods of determining hookworm incidence were displacing the old hit-or-miss methods. As a result, the impression has been gained that the incidence of hookworm infestation in the Islands is less than 20 per cent, and that the Filipinos suffer little, if any, inconvenience from the worms they harbor; in other words, that hookworm disease is nonexistent in the Philippine Islands.

Within the past few years, however, smaller studies have been conducted in and about Manila, extending to small groups of men from certain provinces in various parts of the Archipelago. These studies have shown rather convincingly that the incidence of hookworm infestation can be expected to vary from 40 to 90 per cent in certain of the rural districts. In papers to

[1] Of the International Health Board.

[2] Of the University of the Philippines; assigned to duty with the Philippine Health Service.

[3] Of the Bureau of Science, Manila.

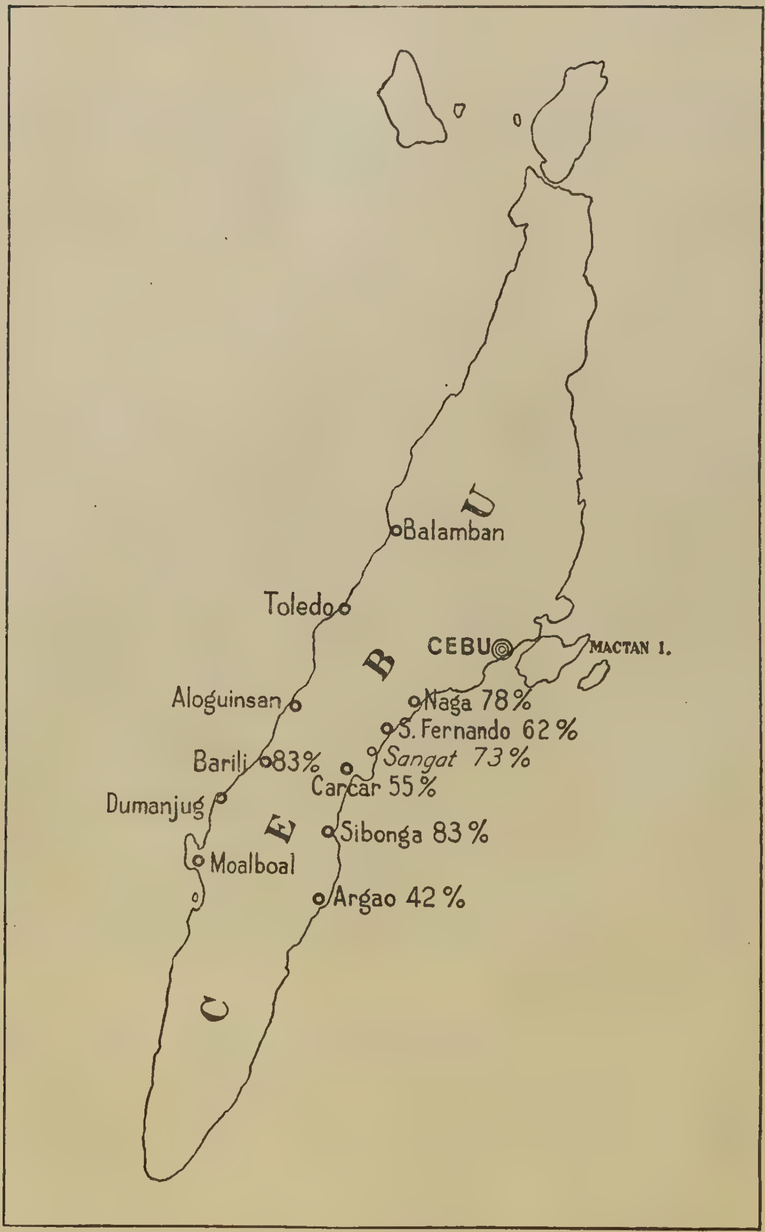

FIG. 1. Cebu Island.

be published in the near future, we shall present figures in support of this statement. We shall, at the same time, endeavor to explain how some of the misconceptions we have mentioned have arisen. It is our intent in this paper to limit our discussion to hookworm disease in Cebu.

During the survey on Cebu we were early impressed by the number of persons presenting themselves for examination and treatment who plainly were suffering from marked anæmia and, in many instances, pronounced œdema. Many of them were forced to rest in chairs after mounting the stairs that led to the improvised laboratory, until they could recover from the very obvious dyspnœa and exhaustion produced by even this slight exertion.

Although the general picture presented by these people indicated that they were suffering from hookworm disease, it seemed to us desirable, in view of the prevailing skepticism, to inquire more thoroughly into their actual physical condition.

This we were able to do through the courtesy of Dr. Augusto Villalon, director of the Southern Islands Hospital, in the city of Cebu, who admitted our patients to his institution and placed all his facilities at our disposal. We desire at this time to record our appreciation of the assistance rendered to us by Doctor Villalon and his staff.

Our time at Cebu was limited, so it was not possible to make an intensive study of the cases. We feel however that, incomplete as our observations are, they establish the existence of hookworm disease on Cebu Island beyond a reasonable doubt.

A few of the more-striking cases that we found at Carcar were sent to the Southern Islands Hospital; others were found in the hospital [4] so that, without any trouble, we found eleven cases of seemingly typical hookworm disease. These were all we could handle in the time at our disposal.

Each subject was given a thorough physical examination, the blood and urine [5] were studied, and the fæces were checked to

[4] Of one hundred twenty-five patients admitted to the Southern Islands Hospital during the month of November, 1922, forty-four, or 35 per cent, were hookworm positive. These figures are based on ordinary study of cover-glass preparations, no concentration having been used. Moreover, the greater number of these positives are represented by patients with obvious anæmia, which led to special examination of their fæces for hookworm ova.

[5] No pathological elements were found in any of the specimens of urine obtained from these patients, so no further allusion will be made to the urine.

make certain that each subject was infested with hookworms. In no instance was evidence secured of the existence of renal disease, malaria, filariasis, or beriberi. Details of the physical and laboratory findings in each subject are given in a series of protocols at the end of this paper.

Of the eleven subjects studied, nine were males. Ages ranged from 10 to 68 years. Nine were laborers or had been occupied as such in the past, one was a housewife, and the other was a schoolgirl. Five patients came from Carcar, while the city of Cebu, and the towns of Liloan, Mandaue, Pardo, and San Nicolas in Cebu, and Ormoc, Leyte, each furnished one subject. Four subjects (cases 1, 2, 5, and 7) had recently undergone chenopodium treatment for hookworm infestation. We recovered small numbers of hookworms from each of these after they had been treated by us with carbon tetrachloride. All four still presented evidence of pronounced anæmia at the time we treated them.

Study of the blood of these patients showed a high-grade anæmia in all. The total erythrocyte counts ranged from 1,380,000 in a heavily infested case to 3,334,000 in a patient previously treated, from whom we recovered only three worms after carbon tetrachloride treatment.

Hæmoglobin estimations, made with the Tallquist scale, ranged from a point below the 10 per cent mark to 70 per cent, the latter in a patient who had been treated before our arrival and from whom we recovered two worms.

Differential counts were made with some difficulty because of the anæmia, and we regard our figures as only approximately correct. No blood parasites were encountered, and in this connection it should be noted that the spleen of only one subject (case 2) was palpable, and that barely at the costal margin.

No case presented an eosinophilia above 7 per cent. Five cases yielded us no eosinophiles on counting 200 leucocytes. These low figures are in harmony with the general picture noted by other observers in severe hookworm disease. Other counts are shown in Table 2.

Most of the cases presented a blood picture that might readily be mistaken for that of a primary anæmia. Marked poikilocytosis and anisocytosis were present in nearly all of the cases, and nucleated red cells were found in cases 2, 3, 5, and 9. All these details are set forth in Table 1 and appear in the protocols.

Preliminary to a discussion of the blood picture and worm counts, it should be stated that stools were collected from the

patients for the two days succeeding treatment, and screened for the recovery of the worms.

TABLE 1.—*Blood picture and worm counts in eleven cases of hookworm disease.*

Case No.	Total erythrocytes.	Hæmoglobin percentage, Tallquist.	Poikilocytosis.	Anisocytosis.	Nucleated red cells.	Eosinophiles.	Worm count after treatment.			
							Ancylostoma duodenale.	*Necator americanus.*	Macerated hookworms.	Total worms recovered.
						P. ct.				
1[a]	3,296,000	70	—	(b)	0	0	2	0	0	2
2[a]	3,334,000	15	+	+	4	3.0	1	3	0	3
3	1,640,000	55	+	+	8	0.5	4	99	0	103
4	2,160,000	—10	+	+	0	0	22	79	13	114
5[a]	1,920,000	15	+	+	5	0	2	9	0	11
6	2,680,000	35	+	+	0	7.0	18	1,274	48	1,340
7[a]	2,130,000	40	+	+	0	1.0	3	15	0	18
8	2,776,000	25	+	+	0	0	26	157	7	190
9[c]	1,380,000	—10	+	+	1	0	(d)	(d)	(d)	(d)
10[c]	2,700,000	45	----	----	----	----	(d)	(d)	(d)	(d)
11	1,760,000	—10	—	—	0	2	(f)	(f)	(f)	1,111

[a] Previously treated for hookworm infection.
[b] Slight.
[c] The worms from this subject were lost in the washing of the stool.
[d] No count made.
[e] Worms were passed by this subject in such a bad state of maceration they could not be counted.
[f] Record lost.

Inspection of Table 1 will show that the worm counts in cases 6 and 11 were very high. So far as we have knowledge, they are the highest that ever have been recorded in the Philippines. It is probable that the yield from case 9 was as high as, if not higher than, either of these, for great masses of worms were seen when the work of washing the stool was in progress. Unfortunately, however, a 15 per cent solution of sodium hydroxide was employed to break down a heavy deposit of thick, tenacious mucus, and the worms shrank and disappeared through the meshes of the screen as if by magic, being lost to view in a few seconds. The subject was a man, 68 years of age, who presented a very extreme picture of hookworm disease.

Cases 3, 4, and 8 present the apparently anomalous picture of a pronounced anæmia coupled with a relatively low worm count. This can be explained, so far as cases 4 and 8 are concerned, by the large proportion of ancylostomes present, amounting in case 4 to 19 per cent of the total number, and in case 8

to 13 per cent of the total number. The total worm count in case 3 is the lowest of these three cases; and, while the relative proportion of ancylostomes is lower than in the other two, it will be noted that the hæmoglobin percentage is 55 as against the —10 and 25 in cases 4 and 8, respectively. These figures represent a startlingly high ancylostome index for the Malay region, but we shall postpone our discussion of that point pending the preparation of our other paper. In passing, attention is drawn to case 6, with a total worm count of 1,340, but with a hæmoglobin percentage of 35. In this case only 18 ancylostomes were recovered.

The general physical examination of the subjects yielded information that harmonizes well with the foregoing. The family and previous personal history of the patients revealed nothing of special bearing on their condition as harborers of hookworms at the time of observation, with the exception of case 10, a girl 10 years old, to whom we shall allude in greater detail farther on.

Every case presented the gross appearance of advanced anæmia. In most instances the conjunctivæ were all but colorless. At least five of the subjects showed the dusky facies that has been styled "hookworm pallor." All showed varying degrees of emaciation from slight to pronounced, as in case 9. Œdema of the extremities was marked in five cases and one subject, case 7, presented a markedly protruberant abdomen. Hæmic murmurs, ranging from slight to pronounced, were elicited in nine subjects. In a word, all the patients were frankly sick and obviously unfit to carry out their ordinary duties, let alone hard manual labor.

One subject, case 4, was suffering from pulmonary tuberculosis in an advanced stage, and the lungs of four others were not above suspicion. There were no other findings of significance in any of the subjects.

In short, a fairly thorough clinical and laboratory study of these people failed to discover any cause for their anæmia other than the hookworms they harbored, and we have no hesitation in stating our belief that they were suffering from hookworm disease in its strict sense.

Detailed discussion of the individual cases would seem to be unnecessary. We desire, however, to direct especial attention to the protocol of case 10, because it presents, in a striking manner, one untoward phase in the problem of education in the Philippine Islands, and shows how at least one child was thwarted

in its efforts to obtain an education. How many thousand other Filipino children are similarly handicapped we cannot, of course, say at the present time. There is nothing in the picture presented by this particular child that is not perfectly familiar to those acquainted with hookworm disease in children; but it is a sad commentary on the indifference and misconception that has led to an almost total neglect of hookworm infections as a factor in the health, education, and economic welfare of the people of the Philippine Islands.

All these patients received treatment with carbon tetrachloride on the basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight. Aside from slight dizziness and drowsiness, none of them exhibited the slightest untoward effects from the treatment. A hyper-secretion of mucus in the intestinal tract, persisting for a number of hours after the treatment, was noted in nearly every case; that will be discussed below. The actual amount of drug administered to each patient is given in the individual protocols. No delayed untoward effects from the drug were observed when all were inspected by one of us (F.G.H.) five days after treatment. At that time several of the patients were allowed to return to their homes. Case 4 was retained in the hospital, because of the advanced stage of her tuberculosis, but her condition was not noticeably modified by the treatment. Others also were detained in order that iron and arsenic might be administered under supervision, for the correction of their extreme anæmia.

Because the time was short, it was found necessary to proceed immediately with treatment, without a preliminary fast. Accordingly, a purge of magnesium sulphate was administered to each patient, the carbon tetrachloride being given as soon as the bowels moved. We believe this to have been a mistake, because the bowel movements following treatment consisted almost entirely, in nearly every case, of a large volume of mucus which we consider to have been the expression of a rather high degree of intestinal irritation, resulting from the combined action of the salts and the carbon tetrachloride.

PROTOCOLS OF CASES

CASE 1

Nemesio Unabia, male, aged 22 years; residence, Carcar, Cebu; occupation, laborer; weight, 38.5 kilograms.

This patient had been previously treated for hookworm.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Father dead, cause unknown; brothers and sisters all living.

Personal history.—Dysentery at 11 years; fracture of rib at 12 years; smallpox in infancy; cholera in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes very pale; conjunctivæ extremely anæmic; skin clear; does not show characteristic hookworm pallor.

Glandular system.—Inguinal glands palpable.

Pulse.—108; regular in rate and rhythm.

Heart.—A.C.D., normal; slight hæmic murmur; otherwise normal.

Lungs.—Normal except for old adhesions at the site of fracture of ribs at right lower side; adhesions in same region on the left side, also at site of old fracture.

Genito-urinary system.—Not examined.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 3,296,000.
Hæmoglobin, 70 per cent.
Polymorphonuclears, 79 per cent.
Eosinophiles, none.
Lymphocytes, 20 per cent.
Large mononuclears, 1 per cent.
Poikilocytosis, —.
Anisocytosis, slight.

Treatment with 7 cubic centimeters of carbon tetrachloride.

Worms recovered on screening, *Ancylostoma duodenale*, females, 2.

CASE 2

Juan Pepito, male, aged 25 years; residence, Liloan, Cebu; occupation, laborer; weight, 52.5 kilograms.

This patient had been treated for hookworm infection on two previous occasions, receiving 15 minims of oil of chenopodium each time.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Mother dead, cause unknown; one brother died of "fever."

Personal history.—"Fever" of two days' duration four years ago; nothing else of significance.

Special senses.—Normal.

Skin and mucous membranes.—Considerable anæmia; oral mucous membranes especially anæmic; skin of palms, soles, and fingers extremely anæmic; depigmentation of skin; no œdema.

Glandular system.—Right epitrochlear glands and inguinal glands palpable.

Pulse.—62; regular in rate and rhythm.

Heart.—A.C.D., not increased; short hæmic murmur, best heard over mitral valve; otherwise normal.

Lungs.—Sounds are normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen.—Palpable at costal margin to the right of midclavicular line.

Liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 3,334,000.
Hæmoglobin, 15 per cent.
Polymorphonuclears, 50 per cent.
Eosinophiles, 3 per cent.
Lymphocytes, 47 per cent.
Poikilocytosis (marked), +.
Anisocytosis (marked), +.

Treatment with 9.4 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale, male, 1.
Necator americanus, females, 2.

CASE 3

Juan Seno, male, aged 25 years; residence, Mandaue, Cebu; occupation, laborer; weight, 49.5 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—One brother dead, cause unknown; one sister dead, cause unknown.

Personal history.—Smallpox in childhood; operation for hydrocele recently; still under treatment.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes extremely anæmic; conjunctivæ extremely anæmic; palms and finger tips very anæmic; no œdema.

Glandular system.—Inguinal glands palpable.

Pulse.—78; regular in rate and rhythm.

Heart.—A.C.D., and sounds are normal.

Lungs.—Impairment of resonance over right posterior lobe; breath sounds prolonged; roughened expiration over areas of impaired resonance; no râles; no cough.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,640,000.
Hæmoglobin, 55 per cent.
Polymorphonuclears, 72.5 per cent.
Eosinophiles, 0.5 per cent.
Lymphocytes, 27 per cent.
Poikilocytosis, +.
Anisocytosis, +.

Treatment with 9.0 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale, females, 4.

Necator americanus:

Males, 54.

Females, 45.

Ascaris (immature), 2.

Oxyuris, 2.

CASE 4

Pelagia Laputan, female, aged 50 years; residence, Carcar, Cebu; occupation, housewife; weight, 36.8 kilograms.

Patient is extremely emaciated. There is considerable swelling over the malar region.

Narcotics.—Tobacco and alcohol in moderation.

Family history.—Father and mother dead, cause unknown; three brothers dead: one murdered, one of infection of the foot, one cause unknown; two sisters dead, one burned, one of "fever."

Personal history.—Smallpox in infancy.

Special senses.—Considerable impairment of hearing, bilateral; slight impairment of sight.

Skin and mucous membranes.—Visible mucous membranes show considerable anæmia; conjunctivæ very anæmic; skin glossy and considerably stretched over upper and lower extremities, hands, and feet as a result of œdema.

Glandular system.—No palpable glands.

Pulse.—68; regular in rate and rhythm.

Heart.—A.C.D., normal; slight hæmic murmur.

Lungs.—Considerable impairment of resonance in right upper lobe, posterior; many fine, crepitant râles, right upper anterior; left chest, anterior and posterior, shows hyper-resonance; emphysema; tuberculosis of right upper lobe.

Abdomen.—Lower half protuberant; no tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Not examined.

Blood findings:

Total erythrocytes, 2,160,000.

Hæmoglobin, 10 per cent.

Polymorphonuclears, 86 per cent.

Eosinophiles, none.

Lymphocytes, 14 per cent.

Poikilocytosis, +.

Anisocytosis, +.

Treatment with 6.7 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale:

Males, 13.

Females, 9.

Necator americanus:

Males, 32.

Females, 47.

Macerated hookworms, 13.

CASE 5

Getulio Umban, male, aged 28 years; residence, Carcar, Cebu; occupation, laborer; weight, 45.6 kilograms.

This patient had been previously treated for hookworm.

Narcotics.—Alcohol and tobacco moderately.

Family history.—All members of family alive and well.

Personal history.—Mumps at 8 years; smallpox in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes extremely anæmic; conjunctivæ very anæmic; palms and finger tips very pale; ashen gray appearance of skin of face; smallpox pittings.

Glandular system.—Inguinal glands palpable.

Pulse.—84; regular in rate and rhythm.

Heart.—A.C.D., slightly increased to left; pronounced hæmic murmur.

Lungs.—Normal.

Genito-urinary system.—Right hydrocele; has been operated upon.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

- Total erythrocytes, 1,920,000.
- Hæmoglobin, 15 per cent.
- Polymorphonuclears, 71 per cent.
- Eosinophiles, none.
- Lymphocytes, 29 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.
- Nucleated red cells, 5.

Treatment with 8.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

- *Ancylostoma duodenale:*
  - Male, 1.
  - Female, 1.
- *Necator americanus,* females, 9.

CASE 6

Meliton Montesa, male, aged 27 years; residence, Ormoc, Leyte; occupation, laborer; weight, 51.1 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—Mother died of tuberculosis; father living; three brothers dead, one of tuberculosis, one of influenza, and one of dysentery; one sister died of unknown cause.

Personal history.—"Fever" of five days' duration in 1922; denies other illnesses.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes and conjunctivæ quite anæmic; skin of palms and finger ends very pale; ashen gray pallor of face; marked œdema of feet and ankles.

Glandular system.—Inguinal glands palpable.

Pulse.—82; regular in rate and rhythm.

Heart.—A.C.D., normal; soft hæmic murmur over mitral valve.

Lungs.—Especially clear, in spite of family history.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

- Total erythrocytes, 2,680,000.
- Hæmoglobin, 35 per cent.
- Polymorphonuclears, 69.5 per cent.
- Eosinophiles, 7 per cent.
- Lymphocytes, 23.5 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.

Treatment with 9.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

- *Ancylostoma duodenale:*
  - Males, 8.
  - Females, 10.
- *Necator americanus:*
  - Males, 658.
  - Females, 616.
- Macerated hookworms, 48.
- *Oxyuris*, 26.

CASE 7

Sebastian Dayap, male, aged 20 years; residence, Inayawan, Pardo, Cebu; occupation, laborer; weight, 34.6 kilograms.

This patient had been previously treated for hookworm. He is extremely emaciated, with protuberant abdomen.

Narcotics.—Alcohol in moderation.

Family history.—Father dead, cause unknown; mother living; two brothers and three sisters living.

Personal history.—Smallpox in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ and visible mucous membranes, palms, and finger tips extremely anæmic; dusky pallor of face; hookworm facies; marked œdema of lower extremities.

Glandular system.—No palpable glands.

Pulse.—100; regular in rate and rhythm.

Heart.—A.C.D., normal; short, soft hæmic murmur.

Lungs.—Antero-posterior diameter somewhat increased; entire chest hyper-resonant; prolonged expiration; breath sounds normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:
- Total erythrocytes, 2,130,000.
- Hæmoglobin, 40 per cent.
- Polymorphonuclears, 73.5 per cent.
- Eosinophiles, 1 per cent.
- Lymphocytes, 25.5 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.

Treatment with 6.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:
- *Ancylostoma duodenale*, females, 3.
- *Necator americanus:*
  - Males, 6.
  - Females, 9.

CASE 8

Macario Lapingkao, male, aged 24 years; residence, Carcar, Cebu; occupation, laborer; weight, 40.1 kilograms.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Three brothers and one sister, all living.

Personal history.—Smallpox in infancy; states he has been pale ever since he was a boy.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ extremely anæmic; visible mucous membranes very anæmic; palms and finger tips anæmic; the man's face exhibits the characteristic hookworm pallor.

Glandular system.—Inguinal glands palpable.

Pulse.—96; regular in rate and rhythm.

Heart.—A.C.D., normal; very pronounced hæmic murmur.

Lungs.—Normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings (100 cells counted):
- Total erythrocytes, 2,776,000.
- Hæmoglobin, 25 per cent.
- Polymorphonuclears, 74 per cent.
- Eosinophiles, none.
- Lymphocytes and mononuclears, 26 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.

Treatment with 7.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:
- *Ancylostoma duodenale:*
  - Males, 9.
  - Females, 17.
- *Necator americanus:*
  - Males, 57.
  - Females, 100.
- Macerated hookworms, 7.

CASE 9

Ruperto Laputan, male, aged 68 years; residence, Carcar, Cebu; occupation, laborer; weight, 44.0 kilograms.

Narcotics.—Alcohol moderately.

Family history.—Three brothers dead, cause unknown; one brother living; one sister died of burns; three sisters living.

Personal history.—Fracture of left leg at 18 years; smallpox at 12 years; abscess of back at 17 years.

Special senses.—Slight impairment of hearing, bilateral; decided impairment of vision; marked arcus senilis.

Skin and mucous membranes.—Conjunctivæ very anæmic; mucous membranes of mouth very pale; palms and finger tips very anæmic; the skin is rough and wrinkled, and lies in loose folds, indicating former adiposity; considerable œdema of the lower extremities.

Glandular system.—Normal.

Pulse.—64; regular in rate and rhythm.

Heart.—A.C.D., normal; prolonged soft hæmic murmur heard over entire A.C.D.

Lungs.—Entire chest is hyper-resonant excepting the right upper posterior; impaired resonance at right upper posterior; many coarse and fine crepitant râles; moist mucous râles?

Genito-urinary system.—Not examined.

Abdomen.—No tenderness; no masses.

Spleen.—Not palpable.

Liver.—Palpable at costal margin.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,380,000.
Hæmoglobin, 10 per cent.
Polymorphonuclears, 76.5 per cent.
Eosinophiles, none.
Lymphocytes, 23.5 per cent.
Poikilocytosis, +.
Anisocytosis, +.
Nucleated red cells, 1.

Treatment with 8.0 cubic centimeters of carbon tetrachloride.

Worms were lost on screening.

CASE 10

Constancia Mendoza, female, aged 10 years; residence, Cebu, Cebu; occupation, student; weight, 24.2 kilograms.

This child was born in Carcar and lived there for eight years.

Symptoms on admission.—Marked paleness, general weakness, dyspnœa and fatigue on slight exertion.

Narcotics.—None.

Family history.—Father and mother living and well; three out of eight children died of smallpox; others are living.

Personal history.—The patient is the fifth child of the family; she had measles and smallpox in early childhood; no other illnesses of importance; the present illness began two years ago with gradually developing pallor

and loss of strength; she attended school for only one year and was obliged to leave school because she was easily fatigued by the journey to and from school; for the last four months she has suffered from persistent constipation, her bowels moving on an average only once a week; on admission she was afebrile and appeared normal except as noted; appetite is fair, sleep normal, bowel movements constipated; her general development and nourishment are fair.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ markedly pale; lips, gums, and buccal mucous membranes anæmic; no hæmorrhage; marked pallor of skin of extremities.

Pulse.—Not taken.

Heart.—A.C.D., normal; sounds normal; no murmurs.

Lungs.—Normal.

Genito-urinary system.—Not examined.

Neck.—No adenitis; bruit du diable heard over right side.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system.—Normal.

Blood findings:

Total erythrocytes, 2,700,000.
Hæmoglobin, 45 per cent.
Differential count not made.

Treatment with 4.4 cubic centimeters of carbon tetrachloride.

Worms were destroyed by maceration, only three being recovered, as follows:

Ancylostoma duodenale, male, 1.
Necator americanus, female, 2.

Bowel movements following treatment were few in number and very scanty in quantity. The patient showed no ill effects from the treatment, however.

CASE 11

Pedro Sabay, male, aged 37 years; residence, San Nicolas, Cebu; occupation, laborer; weight, 49.5 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—Mother and father dead, cause unknown; one brother drowned; two sisters dead, one of cholera, one of bubonic plague.

Personal history.—Mild smallpox at 8 years; unknown illness at 12 years.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ and buccal mucous membranes extremely pale; palms and finger tips show extreme anæmia; ashen gray appearance of face, hookworm pallor; irregular white scars over shins, due to accident.

Glandular system.—Inguinal glands palpable.

Pulse.—68; regular in rate and rhythm.

Heart.—A.C.D., normal; pronounced hæmic murmur.

Lungs.—Impaired resonance, right posterior upper; respiratory sounds slightly prolonged over right upper; no râles.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,760,000.
Hæmoglobin, —10 per cent.
Polymorphonuclears, 71.5 per cent.
Eosinophiles, 2 per cent.
Lymphocytes, 25 per cent.
Large mononuclears, 1.5 per cent.

Treatment with 9.0 cubic centimeters of carbon tetrachloride.

Worms recovered on screening, 1,111.

Differential worm count lost.

ILLUSTRATIONS

[Photographs by C. N. Leach. Map drawn by M. Ligaya.]

PLATE 1

FIG. 1. Case 4. Note swelling over malar region, emaciation of torso, and marked œdema of forearms and lower extremities.

2. Case 7. Note puffiness of face, emaciation of body and upper extremities, and œdema of the legs.

PLATE 2

FIG. 1. Case 2. Previously treated patient, still positive for hookworm and showing protuberant abdomen.

2. Group of subjects at Carcar, all showing symptoms of advanced hookworm disease. Arrow points to case 9, in the group treated at the Southern Islands Hospital.

TEXT FIGURE

FIG. 1. Map of Cebu Island, showing towns surveyed.

Fig. 1. Case 4.

Fig. 2. Case 7.

PLATE 1.

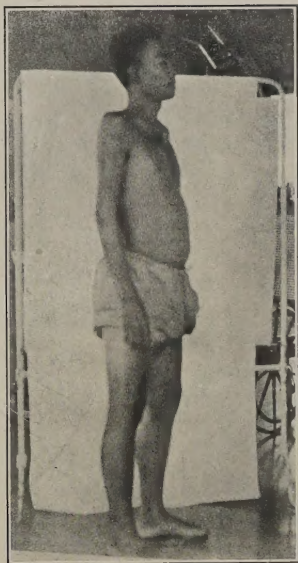

Fig. 1. Case 2.

Fig. 2. Group at Carcar.

PLATE 2.